THE PLANT DISEASE REPORTER

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IN THIS ISSUE

Some remarkable photographs illustrate E. P. DuCharme and L. C. Knorr's article describing vascular pits and pegs associated with diseases in citrus, page 128.

L. C. Knorr and W. L. Thompson summarize spraying trials for the control of Florida scaly bark in citrus; page 143, results support the hypothesis that mites are involved in the development of the disease.

Strawberry plants can be conditioned to withstand temperatures at which virus inactivation occurs, according to observations reported by J. P. Fulton, page 147.

Preliminary investigations reported by R. G. Grogan et al., page 150, indicate that a hitherto unreported disease of head lettuce in California is caused by a strain of the tobacco-ringspot virus.

H. H. McKinney reports the results of studies to facilitate rapid detection of seed-borne virus in Glacier barley seedlings, page 152.

Reaction of barley varieties and selections to physiological races of powdery mildew is reported by J. G. Moseman, page 163.

M. C. Futrell and I. M. Atkins report incidence of diseases of small grains in Texas in 1953, page 167.

J. E. Machacek summarizes results of the 1953 cooperative seed treatment trials, page 169.

A. L. Hooker compares the efficiency of different methods of inducing field infection of corn with the leaf blight and rust organisms in Iowa, page 173.

Results of experiments to determine the effect of crop rotation on population of meadow nematodes in Florida are reported by J. M. Good, Jr., and others, page 178.

Control of foliar nematodes in Bellingham Hybrid lilies can be obtained with hot water-formaldehyde bulb treatment or with a foliage spray of Systox, according to Oregon tests reported by Harold J. Jensen and Fields E. Caveness, page 181.

Observations reported by S. A. Hutchinson and W. F. Mai, page 185, indicate that the predaceous fungus Dactylaria eudermata is not very effective as a control for the golden nematode.

Soil treatment with pentachloronitrobenzene gave good control of both potato scab and Rhizoctonia, according to Iowa experiments reported by W. J. Hooker, page 187.

L. D. Leach et al. report results of lima bean seed treatment trials in California, page 193.

R. R. Libby and D. E. Ellis report transmission of the cucurbit anthracnose fungus by the spotted cucumber beetle, page 200.

Peter A. Ark reports angular leaf spot on squash in California, page 201.

A Panogen drench gives good control of damping-off in nursery flats, according to Peter A. Ark and W. S. Sibray, page 204.

Peter A. Ark discusses some important sources of crown gall inoculum in California orchards, page 207.

Captan gives good control of gray mold rot on strawberries and increases yield as well, according to Illinois tests reported by Dwight Powell, page 209.

Nitidulid beetles will reinfest oak-wilt fungus mats over distances up to 500 feet at least, according to experiments reported by John S. Boyce, Jr., page 212.

G. Flippo Gravatt warns of the danger to walnuts and timber trees of the Pacific Coast from the cinnamon Phytophthora, page 214.

W. A. Campbell and G. H. Hepting report active attack of slash pine in South Carolina by Fomes annosus, page 217; they suggest that the fungus may become a factor of importance.

Observations on diseases of castorbeans in 1953 are reported by D. Donald Poole, page 218.

G. M. Armstrong and Joanne K. Armstrong report cross-inoculation experiments demonstrating that wilt-producing Fusaria from cotton and cassia as well as alfalfa will infect alfalfa, page 221.

Cotton disease losses in 1953, page 223.

Edgar F. Vestal discusses plant disease problems in Jordan, page 226.

Unusual records, page 238: The walnut branch wilt organism on poplar in California, by Joseph M. Ogawa. A correction, page 238. January weather, page 239.

Vol. 38, No. 3--PLANT DISEASE REPORTER--Mar. 15, 1954

VASCULAR PITS AND PEGS ASSOCIATED WITH DISEASES IN CITRUS[1]

E. P. DuCharme and L. C. Knorr

At a time when citrus variety recommendations are being formulated to avoid wood-pitting troubles such as xyloporosis and stem-pitting, it may be pertinent to mention our observations on varietal susceptibility to these and similar disorders under Argentine conditions. The abnormalities intended for discussion are those that show projections either on the outer surface of the woody cylinder or on the inner face of the bark which in turn fit into corresponding pits respectively on the inner face of the bark or on the outer surface of the woody cylinder. The symptoms are obvious to the unaided eye, and, while most often localized at the bud union, they may at times be seen in twigs or roots as in the stem-pitting disease caused by tristeza.

Several types of pitting and pegging are now recognized as symptomatic of particular diseases. Thus Reichert and Perlberger (13) characterize xyloporosis by the presence on the inner face of the bark of small pegs with oblong bases and with tips that are generally brownish; these structures fit into the wood in pits that are conoid and brownish at the bottoms. These symptoms are predominantly localized at the bud union and occur in the wood of whatever species is susceptible.

The stem-pitting disease described by Oberholzer, et al. (12), is characterized by a similar abnormality, except that in contrast to xyloporosis the pits are much longer and resemble strands of twisted twine that run more or less parallel to the grain of the wood. On the inner face of the bark are long projections which fit into pits in the wood. This abnormality, while best seen in the trunk, may also appear in young twigs of budwood age. Stem-pitting is now known to be a varietal reaction to the tristeza virus.

Certain other recognized abnormalities of the vascular system may be mentioned to complete the record as it is known at present. It is doubtful, however, if any of the following diseases are represented in our own material. Fawcett (4) stated that blind pocket produces steep-walled, cup-like depressions 1 to 2 inches long in the wood. When bark is removed from depressed areas, tissues are found which in color are ochraceous salmon and which are impregnated with a hard, gum-like substance. In concave-gum disease (Fawcett, 4), the cavities are somewhat larger, varying from 3 to 6 inches, and are broader than in blind pocket, and generally show crevices through which gum may ooze. In wood-pocket, as described by Fawcett and Calavan (5) the depressions are lenticular, averaging 0.5 to 1.5 inches in diameter, and are colored yellow to ocherous.

The data on which this report is based are derived from 1509 experimental trees in three plots set out in 1947-48 and originally designed to measure varietal susceptibility to tristeza. The plantings were located at the Estación Experimental Citricola, Concordia, E. R., Argentina. All trees became exposed to field-run insects including Aphis citricidus Kirk. (syn.? Paratoxoptera argentinensis Blanch.), A. spiraecola Patch, A. gossypii Glover, and Toxoptera aurantii (Fonsc.). Virus or virus-like diseases known to have been present in the immediate vicinity included tristeza, xyloporosis, exocortis, and psorosis. Of these the first three occurred in commercially destructive amounts. Tristeza had been present in the area for approximately eight years, and all grove trees were already infected whether or not on susceptible rootstocks. Grove trees on Persian sweet lime rootstocks succumbed to xyloporosis (cf. Condado, 2), and trees on trifoliate orange failed because of exocortis (cf. Knorr, et al., 9). Psorosis was present to but a limited extent, and appeared rather definitely correlated with certain budwood sources.

Plot A (Table 1) consisted of 99 stock-cion combinations of 10 cion varieties on 10 different rootstocks set out in 1947. Sixty of the stock-cion combinations were replicated 10 times and the remainder 5 times. In all 800 plants were under observation in this experiment. The cions were budded on the rootstock seedlings from buds of grove trees assumed to contain the tristeza virus. In addition the parent trees were probably also infected with other viruses, though this was not apparent at the time budwood was collected. The rootstock seedlings were budded in place and received two buds. The plants were later pruned to one shoot if both buds grew. These plants were also exposed to insect infestations occurring naturally.

Plot B (Table 2) consisted of 46 graft combinations, the cion and stock plants of which were grown from seeds in an insect-free screenhouse during 1948. On attaining proper size, the paired seedlings were approach-grafted to each other according to the plan in Table 2. When union was successfully accomplished the plants were set out in the open, each combination being

[1] Florida Agricultural Experiment Station Journal Series, No. 260.

Table 1. Types and locations of pitting symptoms observed in 99 graft combinations made by budding 10 rootstock varieties with tristeza-infected buds of 10 cion varieties.

Rootstock[a]	Reaction to tristeza[b]	Pitting		May 1951		Oct. 1952	
		Type	Location	Number of trees			
				Examined	With symptoms	Examined	With symptoms
CION: SWEET ORANGE CHINA SWEET							
Rough lemon	T	Channeling	Trunk and twigs of cion	2	2		
South African		Conoid pit	Trunk of stock			2	1
Grapefruit	S	Channeling	Twigs of cion	2	1	2	0
Foster							
Sweet orange	T	Channeling	Twigs of cion	2	2	2	0
China sweet							
Sour orange	S	None	---	1	0	0	-
Cleopatra	T	Channeling	Twigs of cion	2	1	2	0
Apepú	T	Fluting	Trunk of stock and cion	2	2	0	-
Argentine							
sour orange							
Rangpur lime	T	Fluting	Trunk of stock and cion	2	2	2	0
Persian sweet lime	T	Fluting	Trunk of stock and cion	2	2		
		Conoid pit	Trunk of stock			2	2
Common mandarin	T	Channeling	Cion branches	1	1	2	0
Trifoliate orange	T	Fluting	Trunk of cion	2	1		
Large flowered		Conoid pit	Trunk of stock			2	1
CION: COMMON MANDARIN							
Rough lemon	T	Conoid pit	Trunk of stock	3	2	3	1
Grapefruit	S	Channeling	Trunk of stock	3	2	2	2
Sweet orange	T	Fluting	Trunk of stock and cion	3	1		
		Conoid pit	Trunk of cion			3	1
Sour orange	S	Fluting	Trunk of stock and cion	3	1		
		Fluting	Trunk of stock			2	1
Cleopatra	T	None	---	3	0	3	0
Apepú	S	Fluting	Trunk of stock and cion	3	0	2	1
Rangpur lime	T	Fluting	Trunk of stock and cion	3	2	3	0
Persian sweet lime	T	Conoid pit	Trunk of stock	3	3	3	2
Common mandarin	T	None	---	3	0	3	0
Trifoliata	T	Conoid pit	Trunk of stock	3	2	3	2
CION: GRAPEFRUIT MARSH SEEDLESS							
Rough lemon	S	Conoid pit	Trunk of stock	2	2	2	0
		Channeling	Branches of cion		2		
Grapefruit	S	Channeling	Trunk of stock	2	1	2	2
		Channeling	Branches of cion		1		
Sweet orange	S	Channeling	Branches of cion	2	2	2	0
Sour orange	S	Conoid pit	Trunk of stock	2	1	2	0
Cleopatra	S	Channeling	Branches of cion	2	2	2	1
		Deltoid pit	Trunk of stock				2
Apepú	S	Channeling	Twigs of cion	2	0	1	1
Rangpur lime	S	Channeling	Twigs of cion	2	0	2	1
Persian sweet lime	S	Conoid pit	Trunk of stock	2	2	2	2
		Channeling	Branches of cion		1		
Common mandarin	S	Channeling	Branches of cion	1	1	2	1
		Conoid pit	Trunk of stock		1		
Trifoliata	S	Channeling	Branches of cion	2	2	2	1
		Conoid pit	Trunk of stock		2		

Table 1. (continued)

Rootstock[a]	Reaction to tristeza[b]	Pitting		May 1951		Oct. 1952	
		Type	Location	Number of trees			
				Examined	With symptoms	Examined	With symptoms
CION: TANGELO SAN JACINTO							
Rough lemon	T	Channeling	Twigs of cion	3	0	2	1
Grapefruit	S	None	---	2	0	1	0
Sweet orange	T	Deltoid pit	Trunk of stock	3	0	2	1
Sour orange	S	None	---	3	0	2	0
Cleopatra	T	Deltoid pit	Trunk of stock	3	0	2	1
Apepú	S	None	---	3	0	2	0
Rangpur lime	T	None	---	3	0	2	0
Persian sweet lime	T	Conoid pit	Trunk of stock	3	2	2	0
Common mandarin	T	Conoid pit	Roots of stock	3	1		
		Conoid pit	Trunk of stock and cion			1	1
Trifoliata	T	Conoid pit	Trunk of stock			2	1
CION: TANGELO SAMPSON							
Rough lemon	T	None	---	2	0	0	-
Grapefruit	S	None	---	2	0	0	-
Sweet orange	T	Channeling	Trunk of stock	2	1	0	-
Cleopatra	T	Conoid pit	Trunk of stock and cion	2	2	0	-
Sour orange	T	None	---	2	0	0	-
Apepu	T	Conoid pit	Trunk of stock and cion	2	1	0	-
Rangpur lime	T	None	---	2	0	0	-
Persian sweet lime	T	Conoid pit	Trunk of stock	2	2	0	-
Common mandarin	T	None	---	2	0	0	-
Trifoliata	T	None	---	2	0	0	-
CION: LEMON GALLEGO							
Rough lemon	T	Conoid pit	Trunk of stock	3	3	0	-
Grapefruit	T	Channeling	Trunk of stock	3	2	0	-
Sweet orange	T	None	---	3	0	0	-
Sour orange	T	None	----	3	0	0	-
Cleopatra	T	Conoid pit	Trunk of stock	3	2	0	-
Apepú	T	None	---	3	0	0	-
Rangpur lime	T	None	---	3	0	0	-
Persian sweet lime	T	None	---	2	0	0	-
Common mandarin	T	Conoid pit	Trunk of stock	3	2	0	-
Trifoliata	T	Conoid pit	Trunk of stock	3	2	0	-
CION: LIME BERGAMOTA GROSSA							
Rough lemon	T	Conoid pit	Trunk of stock	3	2		
		Channeling	Trunk of cion			3	1
Grapefruit	S	None	---	3	0	3	0
Sweet orange	T	None	---	3	0	3	0
Sour orange	S	None	---	3	0	2	0
Cleopatra	T	Deltoid pit	Trunk of stock	3	1	2	1
Apepú	S	None	---	3	0	3	0
Rangpur lime	T	Conoid pit	Trunk of stock	3	3	3	2
Persian sweet lime	T	Conoid pit	Trunk of stock	3	3	3	3
Common mandarin	T	Conoid pit	Trunk of stock	2	2	2	0
Trifoliata	T	Conoid pit	Trunk of stock	3	2	3	3

Table 1. (continued)

Rootstock[a]	Reaction to tristeza[b]	Pitting		May 1951		Oct. 1952	
		Type	Location	Number of trees			
				Examined	With symptoms	Examined	With symptoms
CION: KUMQUAT NAGAMI							
Rough lemon	T	None	---	3	0	2	0
Grapefruit	T	Conoid pit	Trunk of cion	2	1	2	0
Sweet orange	T	Conoid pit	Trunk of stock	3	0		1
		Channeling	Trunk of stock and cion			2	1
Sour orange	T	Conoid pit	Trunk of cion	3	2	2	1
Cleopatra	T	None	---	3	0	2	0
Apepú	T	Conoid pit	Trunk of cion	3	0	2	1
Rangpur lime	T	None	---	3	0	2	0
Persian sweet lime	T	None	---	3	0	2	0
Common mandarin	T	Conoid pit	Trunk of cion	3	1	2	1
Trifoliata	T	None	---	3	0	1	0
CION: SOUR ORANGE							
Rough lemon	T	None	---	3	0	2	0
Grapefruit	T	Deltoid pit	Trunk of stock	3	1	2	1
		Channeling	Trunk of stock				1
Sweet orange	T	None	---	3	0	2	0
Sour orange	T	None	---	5	0	3	0
Cleopatra	T	None	---	3	0	2	0
Apepú	T	None	---	2	0	3	0
Rangpur lime	T	None	---	3	0	2	0
Persian sweet lime	T	Conoid pit	Trunk of stock	3	2	2	0
Common mandarin	T	Conoid pit	Trunk of stock	3	1	3	
		Deltoid pit	Trunk of stock				1
Trifoliata	T	None	Trunk of stock	3	0	2	0
CION: SAME AS ROOTSTOCK							
Rough lemon	T	None	---	2	0	1	0
Grapefruit	S	Deltoid pit	Trunk of stock	2	1	1	1
Sweet orange	T	Channeling	Trunk of stock and cion	2	1	1	1
Cleopatra	T	Deltoid pit	Trunk of stock and cion	2	0	1	1
Apepú	T	None	---	2	0	1	0
Rangpur lime	T	Conoid pit	Tap root	2	1	1	0
Persian sweet lime	T	Conoid pit	Tap root	2	1	1	0
Common mandarin	T	Conoid pit	Trunk of stock	2	1	1	0
Trifoliata	T	None	---	0	-	1	0

[a] The rootstock varieties are described in detail only when listed for the first time, and for sake of brevity complete descriptions are omitted when the same rootstocks reoccur.

[b] Reaction to tristeza: S = susceptible; T = tolerant.

Table 2. Types and locations of pitting observed in 46 insect-inoculated stock-cion combinations

Rootstock	Cion*	Pitting		Number of trees	
		Type	Location	Examined	Showing symptoms
Citrus sinensis					
Pineapple	Lemon	Conoid pit	Trunk of cion	4	4
	Tangelo	None		5	0
	Mandarin	None		5	0
	Sweet orange	None		5	0
	Grapefruit	None		5	0
Sweet seedling	Lemon	Deltoid pit	Trunk of cion	4	3
	Tangelo	None		5	0
	Mandarin	None		5	0
	Sweet orange	None		5	0
	Grapefruit	Channeling	Trunk of cion	4	2
C. limon					
Rough lemon	Lemon	Conoid pit	Trunk of cion	4	2
	Tangelo	None		5	0
	Mandarin	None		4	0
	Sweet orange	None		5	0
	Grapefruit	None		5	0
C. reticulata					
Cleopatra	Lemon	Conoid pit	Trunk of cion	4	3
	Tangelo	None		5	0
	Mandarin	None		5	0
	Sweet orange	None		5	0
	Grapefruit	Channeling	Trunk of cion	5	1
Rangpur lime	Lemon	Conoid pit	Trunk of cion	5	4
	Tangelo	Conoid pit	Trunk of cion	5	2
	Mandarin	None		5	0
	Sweet orange	None		5	0
	Grapefruit	Channeling	Trunk of cion	4	2
C. paradisi					
Marsh seedless	Lemon	Conoid pit	Trunk of stock	5	1
	Tangelo	Deltoid pit	Trunk of cion	5	1
C. aurantifolia					
Persian sweet lime	Lemon	Conoid pit	Trunk of stock	5	4
			Trunk of cion		2
	Tangelo	Conoid pit	Trunk of stock	5	4
	Mandarin	Conoid pit	Trunk of stock	5	4
	Sweet orange	None		5	0
	Grapefruit	Conoid pit	Trunk of stock	3	2
		Channeling	Trunk and branches of cion		1
C. reticulata var. austera? x Fortunella sp.?					
Calamondin	Lemon	None		3	0
	Tangelo	Conoid pit	Trunk of stock	4	1
	Sweet orange	None		5	0
	Grapefruit	None		2	0

Table 2 (continued)

Rootstock	Cion*	Pitting		Number of trees	
		Type	Location	Examined	Showing symptoms
Fortunella margarita					
Nagami kumquat	Lemon	Conoid pit	Trunk of cion	3	1
	Mandarin	None		3	0
	Sweet orange	None		5	0
	Grapefruit	Channeling	Trunk and branches of cion	3	1
Poncirus trifoliata					
Trifoliate orange	Lemon	Conoid pit	Trunk and crown roots of stock	3	2
	Tangelo	Conoid pit	Trunk of stock	4	4
		Conoid pit	Trunk of cion		1
	Mandarin	None		4	0
	Grapefruit	Conoid pit	Trunk of stock	4	3
	Sour orange	Conoid pit	Trunk of stock	5	4
	Calamondin	Conoid pit	Trunk of cion	5	1

*The cion varieties used were: Lemon, Villafranca; Tangelo, San Jacinto; Mandarin, Common mandarin orange; Sweet orange, Pineapple; Grapefruit, Marsh seedless.

replicated five times. Inoculation of the tristeza virus was achieved by the feeding of black citrus aphids, Aphis citricidus Kirk., the known vector of tristeza. The aphids for this work were cultured on proven tristeza carrier trees before feeding on the test plants. Since the test plants were constantly exposed in the field plots, they were also hosts to other insects in the field.

Plot C (Table 3) consisted of 57 rootstocks grafted with sweet orange cions during 1948. The rootstock and Pineapple sweet orange seedlings grown from seed in an insect-free screenhouse were paired and approach-grafted. When union was established the plants were set out in field plots, each rootstock being replicated five times. Inoculation of the plants in this study was accomplished in the same manner as was described in the preceding paragraph.

The reactions of some of these combinations to tristeza are indicated in Table 1. A more detailed report on varietal susceptibility to tristeza, for which these plants were originally grown, has been published elsewhere (DuCharme, 3). On terminating the varietal work with tristeza, all plants were stripped of their bark, and records were made of the pitting and pegging present.

As stated at the beginning, our object in reporting these observations is to indicate the extent and type of varietal susceptibility to pitting troubles that occurred in the field. Little else at present can be said on the basis of these preliminary findings. It would be premature to ascribe names that are used and established in other parts of the world since no side-by-side comparison with type material has been possible. Neither is it known to what extent other viruses in the environment may have affected symptom expression. Several papers on varietal reactions to stem-pitting have recently been published, including those by Bitters et al. (1), from California and Grant et al. (6), from Brazil, but only the latter work, in which A. citricidus was used as the inoculating agent, contains any assurance that the pitting symptoms obtained probably resulted from one and the same causal entity.

Table 3. Types and locations of pitting observed in 57 insect-inoculated graft combinations consisting of rootstocks approach-grafted with sweet orange (variety Pineapple) cions.

Citrus species and varieties	Pitting		Number of plants	
	Type	Location	Examined	Showing symptoms
Citrus aurantium L. (Sour orange)				
Crespa rugosa	Honeycomb	Tap root of stock	5	1
Chinotto	Honeycomb	Trunk of stock	4	1
Imperial sour 1	Honeycomb	Trunk of stock	4	3
Imperial sour 2	Conoid pit	On roots of cion roots	5	1
Mirtifolia	None		4	0
C. sinensis (L.) Osbeck (Sweet orange)				
Brazil	Conoid pit	Trunk of stock	5	2
Calderon	Conoid pit	Trunk of stockq	4	1
Criolla temprana	Conoid pit	Trunk and roots of stock	4	1
Do Ceo	Conoid pit, incipient	Trunk of stock and cion	4	1
Dulce de China	None		2	0
Pera	None		3	0
St. Michael	Conoid pit	Crown roots of stock	5	1
Tanger temprana	Conoid pit, incipient	Trunk of stock	5	1
Temprana Santa Anna	Conoid pit	Trunk of stock and cion	4	4
Todo Anno	Conoid pit, incipient	Trunk of cion	5	1
Yoppa	Conoid pit	Trunk of cion	5	3
C. reticulata (Mandarin)				
Ananas	None		4	0
Caazapas	Conoid pit, incipient	Trunk of stock	5	2
Ellendale	None		5	0
Improved	None		3	0
Mandarina comun	Conoid pit, incipient	Trunk of cion	4	1
Martinica	Conoid pit	Trunk of stock and cion	4	1
Oneco (Argentine)	Conoid pit	Trunk of cion	4	2
Parker	None		5	0
Pride of Australia	None		4	0
Santa Lucia	Conoid pit, incipient	Trunk of cion	5	1
Satsuma	Conoid pit, incipient	Trunk of stock	5	1
Scarlett	None		4	0
Yungas	Conoid pit	Trunk of stock	5	1
C. limon (L.) Burm. (Lemon)				
Cereschio	Conoid pit	Trunk of cion	4	1
Cicilia	Conoid pit, incipient	Trunk of cion	4	3
DeDamas	Conoid pit	Trunk of stock and cion	4	1
	Conoid pit	Trunk of stock		2
	Honeycomb	Trunk of stock		1
De La Regina	Conoid pit	Trunk and crown root of stock	4	1
Eureka	None		5	0
Genoa	Conoid pit	Trunk of cion	4	1
Imperial	Conoid pit	Trunk of stock	3	1
	Conoid pit	Tap and lateral roots		1
Ingles	Honeycomb	Trunk of stock	4	3
Kennedy	None		4	0
Napoles	Honeycomb	Trunk of stock	4	1
	Channeling	Trunk of stock		1

Table 3 (Continued)

Citrus species and varieties	Pitting		Number of plants	
	Type	Location	Examined	Showing symptoms
C. limon (L.) Burm. (Lemon) (continued)				
Ponderosa	Channeling	Trunk of stock and main roots	4	4
	Conoid pit, incipient	Trunk of cion		1
Sweet lemon I	Honeycomb	Trunk of stock	4	1
	Conoid pit	Trunk of stock		2
	Conoid pit, incipient	Trunk of cion		1
Sweet lemon II	Honeycomb	Trunk of stock	5	1
	Conoid pit	Trunk of stock		1
	Conoid pit, incipient	Trunk of cion		3
C aurantifolia (Christm.) Swingle (Lime)				
Bergamota grossa	Conoid pit	Trunk and tap root of stock	5	3
Eva	None		4	0
Italia	Conoid pit	Trunk and tap root of stock	4	2
Persian sweet lime	Conoid pit	Trunk of stock	4	4
	Conoid pit	Trunk of cion		2
C. paradisi, Macfad. (Grapefruit)				
Marsh seedless	Deltoid pit	Roots only	4	1
Pernambuco	Conoid pit	Trunk of stock	5	2
	Honeycomb	Trunk of stock		1
Poorman	Conoid pit	Trunk of stock	5	2
	Conoid pit	Trunk of cion		1
C. grandis (L.) Osbeck (Pummelo)				
Calabria	Deltoid pit	Trunk and roots of stock	5	1
Criolla	Deltoid pit	Trunk and roots of stock	4	4
Maravilla de España	None		4	0
Zamboa	Conoid pit, incipient	Trunk of stock	3	2
C. medica L. (Citron)				
Cidra Ingles	Honeycomb	Trunk of stock	4	1
C. paradisi x *C. reticulata* (Tangelo)				
San Jacinto	Deltoid pit	Trunk of stock	5	1
	Conoid pit	Trunk of stock		2
	Conoid pit	Trunk of cion		1

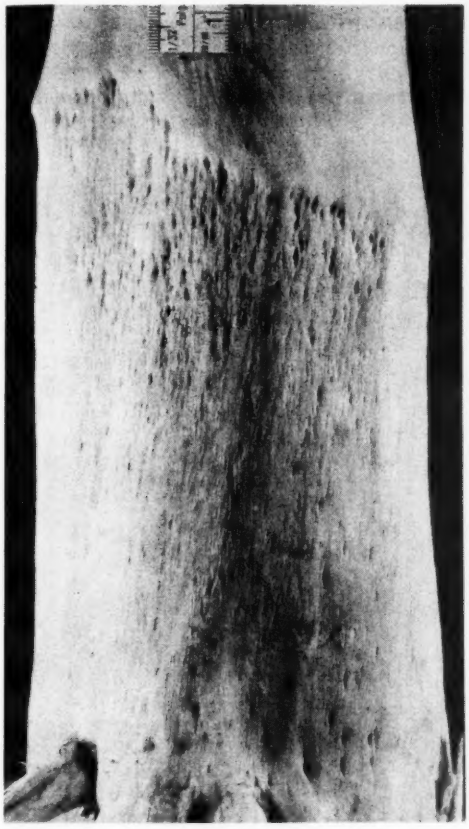


FIGURE 1. Conoid Pit affecting the Persian sweet lime rootstock of a nine-year old sweet orange tree in a state of decline resembling xyloporosis.

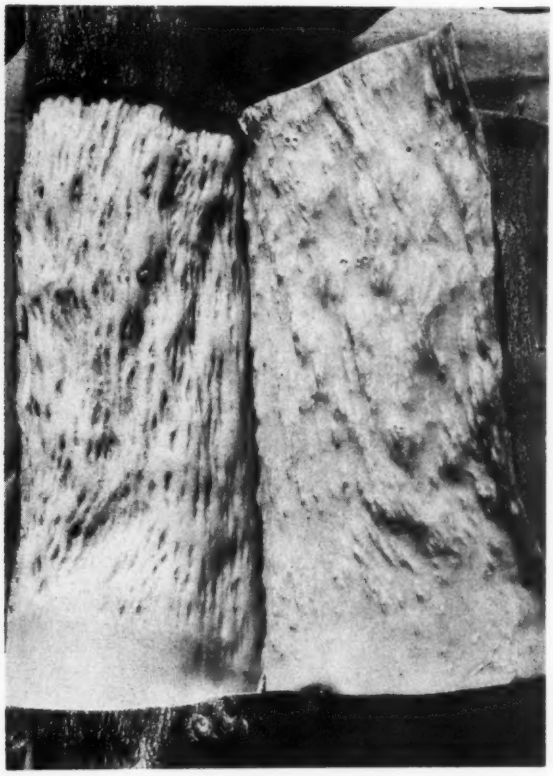


FIGURE 2. Channeling in the Marsh seedless grapefruit cion portion of a six-year-old tree on sweet orange rootstock. Flap of bark on right shows the projections from the inner surface that fit into the pits of woody cylinder. This resembles closely the South African stem-pitting as illustrated by McClean (11).

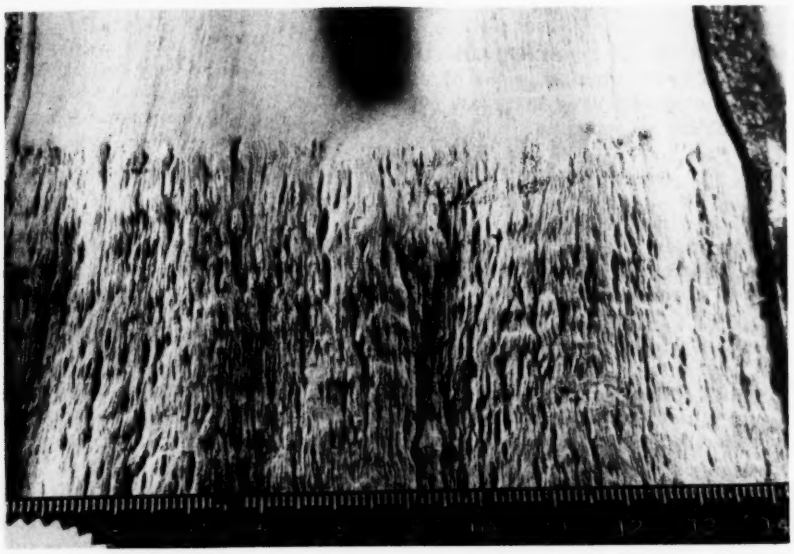
In order to avoid unwarranted conclusions that would result from using names previously established, the following terms have been coined to designate various pitting abnormalities met with in our observations.

1. Conoid Pit: (Fig. 1) pits in the cambial face of the wood, round to oval in outline, averaging 0.5 x 2 mm, with long axis paralleling grain of wood; pits massed at bud union, diminishing beyond; thornlike projections on adjacent portions of the inner face of bark fitting into these pits. This appears to be the same symptom as described by Reichert and Perlberger for xyloporosis, and agreement is further strengthened by the fact that the host ranges of both are similar.

2. Channeling: (Fig. 2) pits much longer than in Conoid Pit, ranging from approximately 10 to 60 mm in length and from 1 to 8 mm in width; depressions in the wood shallow and intertwining with adjacent depressions to give the wood, especially at the trunk, the appearance of being vermiculated; in twigs the pits occur chiefly at the juncture of flushes; ridges project from adjacent portions of the inner bark and fit into the depressions of the wood. Channeling is in all probability synonymous with Oberholzer's "stem-pitting" as previously mentioned by us in another connection (8).

FIGURE 3. Deltoid Pit in the Criolla (common) shaddock rootstock portion of a 3-1/2-year-old sweet orange tree. Flap of bark at right shows the chisel-like pegs that fit into the pits of the woody cylinder.

FIGURE 4. Rugose Wood affecting the rough lemon rootstock portion of a 23-year-old Navel orange tree.



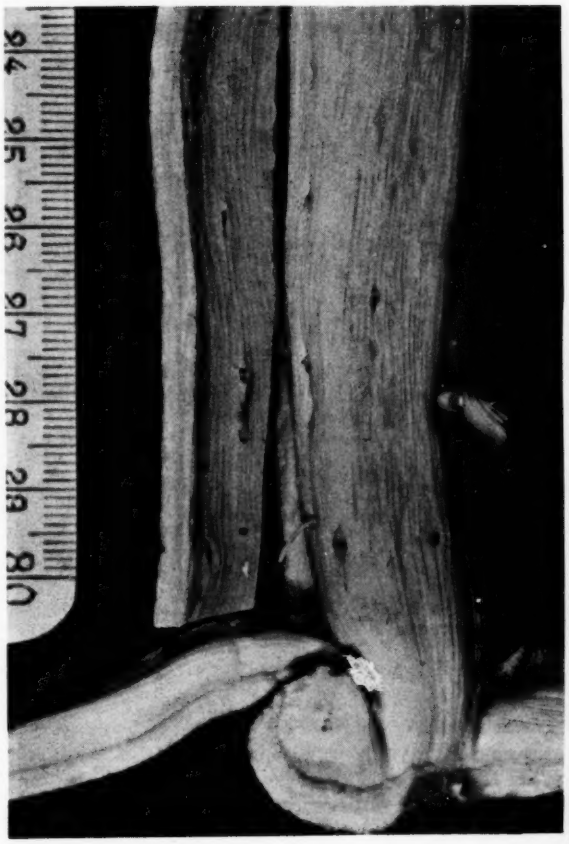


FIGURE 5. Fluting in the wood of a San Jacinto tangelo rootstock portion of a 3-1/2-year-old Criolla (common) sweet orange tree. Note extension of fluting into the crown roots.

FIGURE 6. Honeycombing in the Pernambuco grapefruit rootstock portion of a Criolla (common) sweet orange tree. Note pores or honeycombing in the inner face of the bark on right, and on left the pegs that project into these pores from the adjacent woody cylinder (x 3).

FIGURE 7. Transverse section through the stem of the plant illustrated in Figure 6. Note the hypertrophied medullary rays extending into the bark.

FIGURE 8. False stem-pitting in rough lemon rootsprouts. Bark removed to show the depressions that resemble those of stem-pitting, but which in this case coincided with adult scales of Aonidiella aurantii Mask.

3. Deltoid Pit: (Fig. 3) elongated pits approximately 5 to 25 mm long, paralleling grain of wood; steep-sided; corresponding pegs have chisel-like appearance.

4. Rugose Wood: (Fig. 4) pits elongated, 1 to 8 mm long; narrow, 1 to 2 mm wide; steep-walled; otherwise similar in general appearance and crowded intertwining arrangement to Channeling.

Rugose Wood has been noted chiefly in bearing trees. It was first encountered in a 23-year-old grove of sweet oranges on rough lemon rootstocks in the Territory of Misiones

Table 4. Occurrence of types of pitting symptoms in some citrus species and relatives.

Species	Number of varieties	Type of pitting symptoms					Percent showing symptoms	Number plants examined
		Channeling	Conoid pit	Deltoid pit	Fluting	Honeycomb		
Citrus aurantium L.	7		2		4	5	8	143
C. aurantifolia (Christm.) Swingle	3	1	5				9	70
Persian sweet lime	1		40		2		60	69
C. grandis (L.) Osbeck	4		2	5			43	16
C. limon (L.) Burm.	15		26	3		8	37	101
Rough lemon	1	11					17	64
C. medica L.	1					1	25	4
C. paradisi Macfad.	4	34	5	6		1	35	131
C. reticulata Blanco	14		18	7	5		13	233
Rangpur	1	6			4		16	61
C. sinensis (L.) Osbeck	14	14	34	1	7		15	363
Fortunella margarita (Lour.) Swingle	1	1	6				11	62
Poncirus trifoliata (L.) Raf.	1		30		1		50	62
C. paradisi x C. reticulata	2	1	8				8	110
C. reticulata var. austera ? x Fortunella sp. ?	1		1				5	20

in Northeastern Argentina. The six affected trees were severely stunted and suffering from decline. Upon removal of the bark at the bud union a heavy lenticular pitting was seen to extend in the wood from the union downward. That the rootstocks involved were rough lemon was confirmed by the presence of rough lemon sprouts under these trees. A more detailed account of Rugose Wood has been published previously (Knorr, 7).

5. Fluting: (Fig. 5) accentuated grain in the wood, consisting of narrow paralleling ridges similar in appearance to those on the stems of Equisetum.

6. Honeycombing: (Fig. 6) an abnormality in which the order of the above pitting and pegging is reversed, i.e., the pits occur on the inner face of the bark and the pegs project outward from the woody cylinder. The pits and pegs in honeycombing also differ markedly in size, being so minute as frequently to escape casual observation. Pegs are less than 1.0 mm long. They occur in exceedingly large numbers spaced less than a millimeter apart and give the surface of the woody cylinder a faintly fuzzy appearance. The inner face of the bark is perforated by many minute holes giving in the aggregate the aspect of a honeycomb. Histologic examination shows the pegs to consist of hypertrophied medullary rays (Fig. 7).

Honeycombing appears to bear some relation to tristeza since plot and grove trees in which this symptom occurred were noticeably affected by tristeza. It is conceivable, however, that other diseases may also cause secondary symptoms of this type.

Certain depressions in the wood were dismissed as representing false pitting. Included in this category were dimples caused by partially obliterated root and bud traces in the trunks, and depressions obviously caused by wounds as from hail. A case of pitting was observed in rough lemon rootsprouts that very much resembled the striations produced in stem-pitting (Fig. 8); the pits, however, were found to be correlated with the presence of adults of California red scale (Aonidiella aurantii Mask.).

It will be noted from an examination of Table 4 that no species,of citrus, citrus hybrid, or citrus relative was entirely free of wood pitting. However, within certain species, some varieties were found that did show freedom from pitting (Tables 1, 2, and 3). Reactions to pitting

Table 5. Resistance of some common citrus varieties to pitting when used as cions and as stocks. (Summary of tables 1, 2, and 3.)

Varieties	Cion		Stock	
	Number of plants examined	Percent free of pitting	Number of plants examined	Percent free of pitting
Citrus aurantium L.				
a. Common sour orange	59	100	38	92
b. Apepú (Argentine sour)	3	100	39	90
C. aurantifolia (Christm.) Swingle				
a. Bergamota grossa	50	98	5	40
b. Persian sweet lime	3	100	69	36
C. limon (L.) Burm.				
a. Rough lemon	3	100	66	83
b. Gallego	29	100	0	--
c. Villafranca	41	59	0	--
C. paradisi Macfad.				
a. Foster	3	100	39	67
b. Marsh seedless	73	68	14	86
C. reticulata Blanco				
a. Cleopatra mandarin	3	66	66	85
b. Common mandarin	96	95	43	77
c. Rangpur lime	3	100	67	85
C. sinensis (L.) Osbeck				
a. Common sweet seedling	0	--	27	96
b. Pineapple	276	82	24	100
c. Sweet China	37	57	45	84
Fortunella margarita (Lour.) Swingle				
a. Nagami kumquat	48	83	14	100
Poncirus trifoliata (L.) Raf.				
a. Trifoliate orange	1	100	62	53
C. paradisi x C. reticulata				
a. San Jacinto tangelo	74	68	5	40
b. Sampson	34	88	0	--
C. reticulata var. austera ? x Fortunella sp.?				
a. Calamondin	5	80	14	93

among 20 of the more common citrus varieties are summarized in Table 5. When used as cions considerable freedom from pitting was observed in sour orange, Gallego lemon, Sampson tangelo, and Bergamota grossa lime. On the other hand susceptibility was rather pronounced in Villafranca lemon, Marsh seedless grapefruit, Pineapple and China sweet oranges, San Jacinto tangelo, and Nagami kumquat.

When used as rootstocks, however, the varieties exhibiting high resistance to pitting were sour orange, Pineapple and common sweet oranges, Nagami kumquat, and Calamondin. There was much pitting in Bergamota grossa and Persian sweet limes, Foster grapefruit, common mandarin, and trifoliate orange when used as rootstocks. Only one variety, sour orange, showed high resistance when used either as rootstock or as cion. This is interesting in view of the fact that sour orange is one of the most susceptible rootstocks to tristeza. Other varieties listed in Table 5 are not discussed further because they fall into an intermediate group regarding pitting, or because they are not sufficiently replicated.

It should be pointed out that Conoid Pit showed up in 25.3 percent of the trees in Plots B and C. As mentioned earlier, these trees were grown from seedlings in insect-protected screenhouses and were grafted to each other before being lined out in the test blocks. None of

the trees were budded, yet symptoms resembling xyloporosis developed in the course of three years' growth under field conditions. These observations suggest that xyloporosis may be insect transmitted, a possibility that has not yet been proposed for this disease.

Several shortcomings in the observational data should be pointed out. Despite the convenience afforded by nucellar embryos in obtaining clonal material, there is always the possibility that hybrid seedlings may accidentally be propagated. These genetically variable plants when mixed with nucellar or clonal seedlings could be responsible for introducing susceptibility within a variety otherwise resistant. Trees were examined when they were between three and four years old, and at that early stage it was often difficult to distinguish incipient Conoid Pits from incipient pits due to Channeling. It is also possible that some varieties listed as unaffected might later have developed symptoms, and that those with incipient symptoms might in time have shown more obvious effects. Premature termination of these trials was made necessary by the closing of the Tristeza Laboratory and the return of personnel to the United States.

The number of replications is small in some cases, and the data cannot be taken to elucidate varietal susceptibility to any particular disease nor to indicate what diseases were actually present. Neither is it possible to tell whether some forms of pitting, as for instance Deltoid Pit, were of any economic importance.

Tree vigor apparently had some effect on the development of pitting. Within a set of susceptible replicates, vigorously growing trees manifested distinct symptoms of pitting whereas stunted trees of the same variety often showed no pitting.

In comparing the above results with those reported by Grant, et al. (6) from Brazil and by Bitters, et al. (1) from California, certain discrepancies become evident. For instance, Bitters states that as a group grapefruit was least affected by pitting due to tristeza. This is quite in opposition to the highly susceptible condition described for this species in Brazil and Argentina. On the other hand Bitters reports the severest stem-pitting to have been found in Palestine sweet lemon whereas this variety as grown commercially in Argentina is considered to be tristeza tolerant. Palestine sweet lemon is much pitted in Israel, where tristeza is not known (Littauer, 10), but the pitting is attributed to xyloporosis. Reasons for regarding xyloporosis to be different from tristeza have been summarized by Wallace (14).

Another divergency in results involves Poncirus trifoliata, which was reported in California to show very extensive pitting, 80 percent of the trees examined being affected. In Brazil, on the other hand, the sample tested was found 100 percent free of pits. In Argentina, the reactions were similar to those in California. Fifty percent of the plants on P. trifoliata were pitted in the stock (cf. Table 4); the pitting, however, was of the conoid type which suggests the possibility that P. trifoliata is also susceptible to xyloporosis. Here again, as in the case of xyloporosis discussed above, the cause of pitting was apparently insect transmitted. There is a possibility that xyloporosis and exocortis are the same disease, especially in view of the Conoid Pits observed in trifoliate rootstocks affected by exocortis, but our data are inadequate to substantiate this hypothesis.

As a further example of divergent results among various investigators may be cited the presence in California of extensive pitting in sour orange, whereas in Brazil, Argentina, and more recently in our work in Florida, sour orange has not been found (except in a few experimental trees (Tables 1, 2, and 4)) to show pits of the conoid type (Fig. 1) despite the sampling of thousands of trees.

One possible explanation for these differences is that various kinds of pitting have been confused. Those observed by Grant, et al. and Bitters, et al. are reported to be caused by the tristeza virus, while those mentioned in this paper are obviously the result of several viruses including tristeza and xyloporosis. But even within the context of the two papers that attribute the pitting described to tristeza, there remain many differences. These may be due to strain variations in the tristeza virus, or to differences in the methods of inoculation. The Brazilian plants were insect-inoculated while those in California were inoculated by means of buds. Of the two carriers, the vectors are more likely to separate different viruses from mixtures that might exist in the source material, while buds may be presumed to transmit all components of the mixture.

This likelihood has been borne out many times in work with other viruses, but in our material under Argentine conditions, the similarities resulting from insect and bud inoculations are rather marked and surprising. Tables 1, 2, and 3 when compared show essentially the same host range and type of pitting in each variety, whether insect- or bud-infected. In a way this might be expected, since originally all budwood sources must have been insect-inoculated in the field. A further possibility is that one species of vector may transmit not only the tristeza vi-

rus but also one for xyloporosis or some other troubles, an indication suggested by the occurence of xyloporosis-like pits in the insect-inoculated material of Tables 2 and 3.

Other possible explanations for lack of agreement are that in the different areas various strains exist, that different viruses, virus mixtures, or vectors occur, and that symptoms are affected by diverse growing conditions. That virus strains or different viruses or mixtures may be involved is suggested by the unusual type of pitting in sour orange wood pictured by Bitters, et al. This bubble-type pitting bears no resemblance to anything that has yet been seen by us in Argentina or in Florida. Comparisons with pitting reported from Brazil are not possible in the absence of illustrations in the paper by Grant, et al. (6).

In spite of the conditional factors brought out above, the data do have some commercial significance. Trees found to be resistant to pitting in these tests were of the same varieties that in Argentine groves grew satisfactorily and without pitting. The data are in line with observations made on 407 trees in numerous commercial groves. The trees were examined externally and in addition bark was peeled from around the bud union, the roots, and the twigs to determine presence of pitting. Trees sampled included such familiar combinations as grapefruit on rough lemon, sweet orange and sour orange; sweet orange on rough lemon, sweet orange, sour orange, Persian sweet lime, and trifoliate orange; and tangerines on sweet orange and trifoliate orange.

The data from the experimental plots show that many untried rootstocks may develop pitting troubles. This re-emphasizes the recommendation that only tried and proved varieties should be used in commercial practice and that new varieties should be adopted only after they have been thoroughly tested and found acceptable.

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SPRAYING TRIALS FOR THE CONTROL OF FLORIDA SCALY BARK IN CITRUS[1]

L. C. Knorr[2] and W. L. Thompson[3]

Florida scaly bark, once the object of an internal quarantine that prohibited the movement of nursery stocks from 120 towns in nine of Florida's leading citrus counties, is today a disease on the verge of extinction. That the State Plant Board quarantine of 1917 was probably not in itself the cause for arresting this disease is indicated by the fact that by 1925 scaly bark had spread farther into an additional eight counties. Since then, however, the course of the disease has altered sharply, so that today scaly bark is to be found only in a few neglected groves on the East Coast of Florida.

The rather sudden and almost complete disappearance of scaly bark (or nailhead rust as it is called from effects on the fruit) is as remarkable as the unwitting manner of its conquest. For many years, dating from the researches of Fawcett in 1911 (1), this disease was thought to be caused by a fungus, Cladosporium herbarum var. citricola. In view of this conclusion, spraying with Bordeaux mixture was logically recommended, but control with copper never proved to be a spectacular success.

In the mid-twenties, several new ideas in grove care gained general acceptance. One was the use of lime-sulfur for scale control. Later, improved methods of insect and mite control were developed which led to greatly increased use of pesticides. Today the State's citrus industry applies annually some 90,000,000 pounds of sulfur, 2,140,000 pounds of copper, and 4,590,000 gallons of oil in combatting insect pests and plant disease. In the course of this advance, Florida scaly bark disappeared quite unobtrusively and without any special measures having been taken for its control.

One explanation for the sudden decline of this disease is suggested by a recent note (3) questioning the primary fungal nature of scaly bark and demonstrating that the condition is associated with the feeding of a species of mite (tentatively determined to be Brevipalpus australis (Tucker)). On the basis of this information, it may be presumed that scaly bark disappeared because of increasing use of sulfur insecticides that incidental to their main purpose happened also to control the mites. It is known that other species of false spider mites are susceptible to sulfur-containing insecticides.

The recent advent of the frozen concentrate industry has revolutionized many aspects in the production picture. One change resulting from the greater utilization of fruit for concentrating and canning has been the gradual decrease in spraying intended primarily to improve appearance of the fruit. If this trend continues, a point might ultimately be reached where pests long under control will again emerge and become destructive.

In line with a policy of preparedness for such contingencies, it was thought advisable to learn the means needed to control any possible outbreaks of scaly bark. Preliminary spray trials were set up in the spring of 1950 in an East Coast sweet orange grove where scaly bark still persists in destructive amounts. Information resulting from these trials would also confirm, under field conditions, the existence of a relationship between the presence of Brevipalpus and the occurrence of scaly bark.

Procedure

To test the ability of pesticides to control Florida scaly bark, spray plots were located in a grove at Oak Hill where the disease had been a commercial problem for many years. Losses occurred annually from the dropping of affected fruits and leaves, the cankering of twigs and limbs, and the blemishing of fruits that led subsequently to their being culled out in the packinghouse. Trees in the grove were about 20 years old and averaged 15 feet in height. None of the trees had ever been sprayed.

The layout consisted of five replicated blocks, which were divided into four-tree subplots with trees arranged in the form of a square. An unsprayed buffer row separated each subplot. Subplots were randomized throughout the five replications. Ten of the subplots were reserved as unsprayed checks.

To obtain information on the matter of proper timing, three schedules were devised. One

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Table 1. Effects of treatments on Brevipalpus mite counts and on incidence of nailhead rust. 1950 experiments, counts made at dates shown.

Spray material	Pounds per 100 gals.	When applied: Dormant[a]	When applied: Post bloom[b]	Brevipalpus per 1200 inches of twigs (No.): Feb. 23	Brevipalpus per 1200 inches of twigs (No.): May 2	Percent of fruit affected by nailhead rust: Aug. 24
Sulfur-containing materials:						
Wettable sulfur	10	X		0	1	0.5
Wettable sulfur	10	X	X	0	11	0.4
Wettable sulfur + Tribasic copper sulfate	10 2	X		0	6	0.1
Wettable Sulfur + Tribasic copper sulfate	10 2	X	X	3	6	0.6
Wettable sulfur + Tribasic copper sulfate	10 3	X		0	36	0.1
Wettable sulfur	10		X	104[c]	1	1.8
Wettable sulfur + Tribasic copper sulfate	10 2		X	[e]	6[d]	3.2[d]
Dinitro-o-cyclohexyl-phenol-containing materials:						
DN Dry Mix	0.66	X		0	2	0.4
DN Dry Mix + Tribasic copper sulfate	0.66 3	X		0	7	0.5
Bis (p-chlorophenoxy) methane-containing materials:						
Neotran	2	X		116	131	13.3
Neotran	2	X	X	83	63	3.1
Copper-containing materials:						
Tribasic copper sulfate	2	X		849	284	15.1
Tribasic copper sulfate	2	X	X	303	514	16.3
Tribasic copper sulfate	3	X		225	787	22.7
Unsprayed checks:						
Check 1	--	--	--	358	159	13.8
Check 2	--	--	--	203	154	9.2

[a] Dormant sprays applied January 19 and 20.
[b] Postbloom sprays applied March 22.
[c] Count before application of postbloom spray.
[d] Based on only 10 trees in a single, unreplicated block. Omitted in the calculation of Pearson's coefficient of correlation.
[e] Not counted.

was designed to test the efficacy of a dormant spray only, the second to test a combination dormant-postbloom spray, and the third to test a postbloom spray alone. The dormant sprays were applied on January 19 and 20, 1950 in advance of blossom break. The postbloom spray was applied March 22, 1950 when petal fall was more than 90 percent complete.

Sprays were applied with a power take-off Hardie sprayer developing pressures between 400 and 600 pounds. Precautions were taken to avoid spray drifts to adjacent plots, and wind conditions were such as to have minimized this danger. The amount of spray applied per tree varied owing to differences in tree size; the rule was therefore adopted of spraying until all foliage was thoroughly wetted.

Thirteen treatments were applied as listed in Table 1. Sulfur was included because of previous work showing Brevipalpus mites to be susceptible to this material. Copper was introduced because reports from South America claimed it to be a necessary ingredient for control. Bis

(p-chlorophenoxy) methane (Neotran), and dinitro-o-cyclohexyl phenol (DN Dry Mix) were included to determine their specificity for the Brevipalpus mite in question.

Four weeks after the dormant application and five weeks after the combined dormant-postbloom sprays, counts were made of mites surviving on five 12 inch lengths of twig growth from each of the trees in the experiment. A count was also made on September 25, 1950 of fruits with lesions occurring on sprayed and unsprayed trees. These lesion counts as well as the post-spray mite counts formed the basis for evaluating the effectiveness of the various spray treatments.

Results

Table 1 summarizes the effects of spray treatments on the population of Brevipalpus mites within the test plots. Counts were obtained one month after application of dormant sprays, and five weeks after the combined dormant-postbloom sprays. Both sets of figures show a marked reduction in the number of mites -- almost to the point of complete eradication -- in trees sprayed with either wettable sulfur or DN. Control with Neotran at 2 pounds per 100 gallons of water was inferior to that obtained with the foregoing materials. Tribasic copper sulfate, when used in the absence of sulfur or DN, actually increased (more than doubled) the number of mites over those present in the unsprayed checks. Figures are based on total mites present on the 1200 inches of twigs derived from all 20 trees of each treatment.

The effect of the 13 treatments in reducing spotting of the fruits is also summarized in Table 1. In controlling nailhead rust, the most effective materials were found to be wettable sulfur and DN. Control with Neotran was only partial. When tribasic copper was used alone, without mixture with sulfur or DN, the amount of fruit spotting was greater than when no spray was used at all.

With regard to timing, indications are that a single dormant spray is more effective than a single postbloom spray, and equally as effective as a combined dormant-postbloom application. The dormant spray is further to be preferred because of its greater margin of safety and because of its greater economy over a combined dormant-postbloom application.

Discussion and Conclusions

The results obtained in the control of nailhead rust closely parallel those for the control of Brevipalpus mites. In fact when a linear correlation coefficient is calculated involving the number of mites present on May 2 and the amount of nailhead fruit spots occurring on August 24, the value is found to be of the high degree of positive correlation indicated by

$$r_{yx} = 0.9331.$$

This fact gives further support to the suggestion that Florida scaly bark depends on the presence of false spider mites rather than direct attack by a fungus. The association, however, does not necessarily implicate the mites directly, and still leaves unsettled the question as to whether the primary causal agent is the mite itself or whether the mite acts as the vector of a virus or some other causal agent.

These conclusions are in agreement with those reached in South America where, according to Frezzi (2), the lepra explosiva of Argentina is caused by Tenuipalpus pseudocuneatus (Blanchard), another of the Phytoptipalpidae. This lends increased justification for considering the names Florida scaly bark (nailhead rust, leprosis) and lepra explosiva to be synonymous for this general type of disease (4).

In view of the above results, it can be concluded that safe and economical control of Florida scaly bark and nailhead rust can be obtained with one yearly application of wettable sulfur, 10 pounds per 100 gallons of water, when applied as a dormant spray.

Summary

On the basis of recent findings that Florida scaly bark (syn. nailhead rust, leprosis) is not due to a fungus, as long believed, but rather to the feeding of Brevipalpus mites, various miticidal sprays were tested for the control of this disease. Included were wettable sulfur, DN Dry Mix, and Neotran; tribasic copper sulfate was also tested to check previous reports. These materials were applied in the spring as prebloom, postbloom, and combined pre- and postbloom sprays. Counts of the associated Brevipalpus mites five to six weeks after applications showed

sulfur and DN to give almost complete control, Neotran to provide only partial control, and copper sulfate to lead to a considerable increase in numbers of mites over those present in the unsprayed checks.

Counts of nailhead rust lesions on fruits six months after postbloom spraying showed control to parallel the destruction of mites. A Pearson correlation coefficient of 0.9331 indicates a high degree of association between the presence of Brevipalpus mites and the amount of fruit spotting.

On the basis of these spray trials it is concluded that Florida scaly bark can be economically, thoroughly, and safely controlled by a single yearly spraying with wettable sulfur, 10 pounds per 100 gallons of water, when applied just in advance of the spring flush of growth.

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HEAT TREATMENTS OF VIRUS-INFECTED STRAWBERRY PLANTS[1]

J. P. Fulton

Observations have indicated that the virus content of infected Blakemore strawberry plants is modified by holding the plants at warm temperatures. In at least one case a plant has been rendered apparently virus-free by this treatment. The results are similar to those recently reported by Posnette (5) on heat therapy of virus-infected strawberry plants in Britain. He reported that several viruses were inactivated at different lengths of time and at temperatures ranging from 33° to 37° C. The presence of at least two viruses was indicated in a single plant by a differential reaction of the viruses to heat.

The author (2) has reported the occurrence of viruses in Arkansas strawberry plantings. Upon indexing to Fragaria vesca, strawberry plants of the variety Blakemore usually yielded a mixture of type 1 and type 2 viruses as described by Demaree and Marcus (1). Occasionally plants yielded a mild mottle. Rarely a plant yielded the type 2 virus.

Various trials with heat treatment of strawberry plants have been disappointing owing to the fact that the plants were all too often killed by treatments. R. H. Fulton (3) has reported negative results in attempts at virus inactivation with hot water using the variety Robinson. The author has obtained similar disappointing results with the variety Blakemore. Miller (4), however, was able to obtain virus inactivation with hot water treatment, although the percentage of plants surviving the treatment was low.

Early work with plants in dark constant-temperature chambers held at several temperatures between 38° and 42° C failed to give positive results. In all cases plants were killed before any virus modification could be demonstrated. It was found, however, that plants could be subjected to fairly high temperatures when held in a plastic covered chamber in a greenhouse. A chamber was constructed with heating elements to maintain a minimum temperature of 31°. No attempt was made to ventilate the chamber and the summer temperatures during the day often rose to 48°. Plants have remained alive in such a chamber for six months and can apparently be maintained much longer. When vigorous plants which have been growing at a cool temperature (18°) are moved into such a chamber, a large percentage of the plants die. If, however, the plants are conditioned for several weeks by growing them at a warm temperature (27°), very few plants die when they are moved into the chamber.

The observations reported here are based upon Blakemore plants from a single clone infected with type 1 and type 2 viruses as demonstrated when plants were grafted to the indicator plant. (Figure 1). Plants were placed in the chamber described above for three months during the summer of 1952. Indexing of the plants was begun the following winter and has continued on some of the plants to November 1953.

The indicator plants used in these studies were of a clone obtained from a seedling of a cross between Fragaria vesca (East Malling Clone) and an alpine variety of F. vesca (Baron Solemacher). As far as this clone has been tested, it gives virus symptom expression essentially the same as that obtained with the East Malling Clone. It has the advantage of being a more robust plant with thicker runners. (Figure 2).

The virus content of all of the plants receiving heat therapy during the summer of 1952 was modified. Upon indexing to the indicators, milder symptoms were obtained from most of the heat-treated plants than from the original plants which were not held in the chamber. The symptoms closely resemble those that have been described for type 1 (1). Plants were somewhat stunted, showed mottling and some puckering of leaves. There was, however, no extensive proliferation of the crowns and the plants retained a fair ability to produce runners. The contrast between the reaction obtained from untreated plants and from plants with the modified virus content is shown in Figures 1 and 3. A few of the heat-treated plants appeared to be virus-free when first indexed. Later, however, these plants regained their ability to transmit the virus and yielded the same symptoms on indicator plants as those described above. (Figure 3). One plant was obtained that is apparently virus-free. Plants from this clone have been indexed repeatedly for the past 14 months and have never produced any symptoms on indicator plants.

These results confirm the report by Posnette (5) that the virus content of infected strawberry plants can be modified by heat and in some cases the plants can be rendered virus-free. There is no indication that the viruses used in the present study are the same as those used by Posnette.

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[1] Research paper No. 1096, Journal Series, University of Arkansas. Published with the permission of Director of the Arkansas Agricultural Experiment Station.

FIGURE 1. Indicator plant (Fragaria vesca cross) infected with type 1 and 2 viruses from the Blakemore clone used in these studies

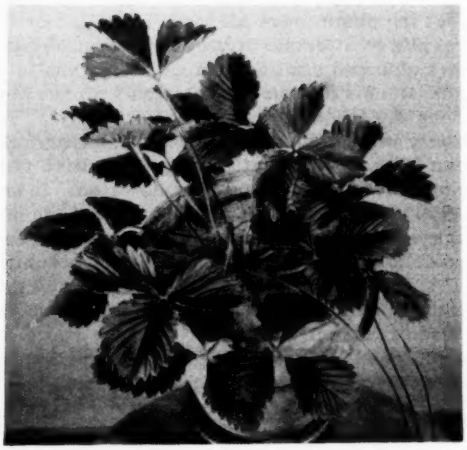

FIGURE 2. Indicator plant (Fragaria vesca cross) virus-free.

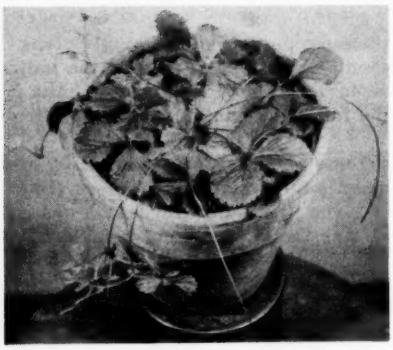

FIGURE 3. Indicator plant (Fragaria vesca cross) infected with modified virus content following heat treatment of Blakemore clone.

The work reported here confirms the reports of others (4, 5) that heat treatments may be a valuable tool in the study of strawberry viruses. It is not known from the present study whether the virus modification was obtained by short bursts of high temperatures during the sunny part of the day or by holding the plants for long periods at a relatively warm minimum temperature. An essential feature of the observations was that strawberry plants could be conditioned to withstand temperatures at which virus inactivation occurs. It seems logical to assume that a method can be developed which will consistently yield virus-free strawberry plants.

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FIELD OCCURRENCE OF AN UNUSUAL VIRUS DISEASE OF HEAD LETTUCE

R. G. Grogan, Roy Bardin, and W. C. Schnathorst

In October of 1953, a hitherto unreported disease of lettuce was observed in a 15-acre field of the Great Lakes Variety growing in the Salinas Valley near Greenfield, California. Infection was confined for the most part to a strip not more than 200 feet wide running diagonally through the field. Within this strip the percentage of infection varied from 5 to 25. At the time of first observation, the plants were in the late rosette stage. Inspections were made periodically until harvest, but no further spread was noted either within the field or to adjacent fields. Wild and cultivated plants within the immediate area were also examined, but no potential sources of inoculum were found.

Affected plants exhibited a variety of symptoms, for the most part on the older and intermediate leaves. Thsee symptoms ranged from a diffuse yellow mottle with yellow ring spots to a brilliant yellow or white calico-like pattern (Fig. 1). Although no necrosis was observed initially, the infected leaves later developed a dull yellow color and in some instances died completely. Most of the infected plants were severely stunted with the result that heads were so greatly reduced in size as to be unsuitable for harvest.

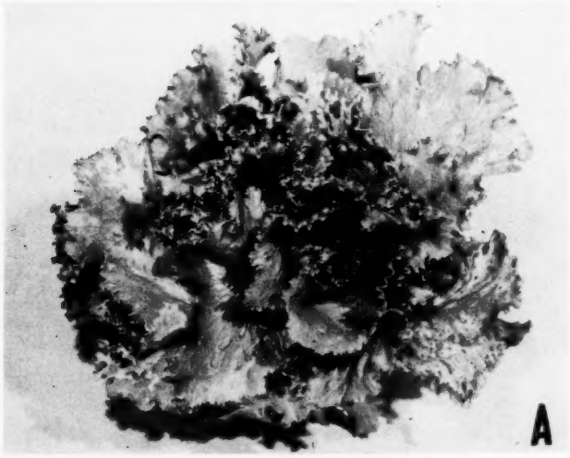

FIGURE 1 A.
Great Lakes lettuce plant showing typical symptoms resulting from infection in the field.

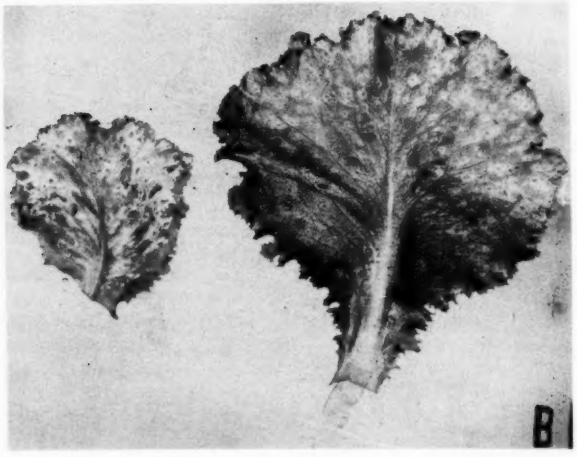

FIGURE 1 B.
Intermediate (left) and older (right) leaves showing calico-like patterns and ringspots.

The type of disease symptoms and pattern of distribution in the field suggested that the incitant of the disorder might be a virus. Infected plants were brought into the laboratory for use as inoculum in mechanical transmissions to several hosts, viz: Nicotiana glutinosa, N. tabacum, N. rustica, petunia, cowpea, and Bountiful bean. The symptoms produced on these plants agreed closely with those reported for tobacco-ringspot virus[1]. Reinoculations from these hosts to head lettuce varieties gave symptoms identical with those observed in the field. Further research is in progress to establish more definitely the relationship of the lettuce virus to strains of tobacco-ringspot virus and other plant viruses.

Wingard[1] reported infection of wild lettuce and head lettuce following artificial inoculation with tobacco-ringspot virus, but the leaf symptoms that he described did not include calico-like patterns and ringspotting.

Insofar as the writers are aware, this is the first report of the natural occurrence of a tobacco ringspot-like virus in head lettuce.

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[1] Wingard, S. A. 1928. Hosts and symptoms of ringspot, a virus disease of plants. Jour. Agr. Res. 37: 127-153.

CULTURE METHODS FOR DETECTING SEED-BORNE VIRUS IN GLACIER BARLEY SEEDLINGS

H. H. McKinney[1]

INTRODUCTION

The results of studies to facilitate the rapid detection of seed-borne virus in Glacier barley conducted from June through December 1953 at Beltsville, Maryland, are summarized here. The object was to induce a satisfactory expression of chlorotic markings in the first three leaves, or if possible the first leaf, of all seedlings from virus-infected seed, thereby making it unnecessary to assay plants for latent virus, thus permitting early disposal of the infected seedlings before they can infect healthy seedlings growing nearby.

Testing barley seedlings for seed-borne virus of the type culture of the stripe-mosaic (false stripe) virus[2] (1, 2, 3, 4) has presented no striking difficulty in the varieties tested, as chlorotic markings are detectable over a wide range of culture conditions. However, difficulty is encountered with the mild and the very mild symptom-inducing viruses that predominate in the seed of certain varieties of barley, and which appear to be closely related to the stripe mosaic virus. Like the latter, these mild-acting viruses induce local chlorotic lesions in the leaves of Chenopodium album, and systemic markings in wheat, green foxtail, smooth crabgrass, and sweet corn. In sweet corn, one virus isolate induces only local lesions. The degree of chlorotic expression is not constant for all of the isolates in any one of the plant species tested, and some of the species are not genetically uniform for susceptibility to a given isolate.

Particular attention was given to infected seed of Glacier barley supplied by R. F. Eslick (5). Traces of virus of barley stripe mosaic occur in Glacier, but the mild symptom inducing viruses predominate.

Certain resistant or semiresistant varieties including Oderbrucker may be difficult to index for the type virus of stripe mosaic at times. In such varieties, mild symptom-inducing virus from Glacier may be more difficult to index than in Glacier. In very susceptible varieties, such as Atsel, indexing may offer no serious problem with any of the seed-borne barley virus isolates now under observation.

It was observed that the mild symptoms characteristic of Glacier No. 18[3] from infected seed were more pronounced with advance of spring, than they had been in an earlier test (3) conducted in a glasshouse during the previous autumn and winter. It also became evident that virus-free seedlings can become infected by contact with infected seedlings when more than one seedling is grown in a pot.

EXPERIMENTAL

About 3,500 seedlings and plants from infected seeds of Glacier barley and about 1,000 from infected seeds of other varieties of barley were studied under several conditions in a greenhouse, in controlled temperature chamber, in light rooms, in total darkness, and out-of-doors. The plants were grown in clay pots, boxes, and outdoor plots. All seed of a given line was from the same well-mixed lot.

Degrees of chlorotic expression are difficult to measure without special equipment, which was not available. When the expressions were extremely mild, two and sometimes three observers worked together, in order that slight differences might be recorded on as objective a basis as possible, and to facilitate recollections of previous tests for between-test comparisons. The diagnosis of very mild chlorotic markings is aided greatly by the use of a magnifier. An Edroy 2 1/4-x binocular magni-focuser is worn on the head, leaving both hands free. Daylight was used for detecting faintly chlorotic markings.

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[1] The author acknowledges the assistance rendered by Matthew Koerner and Henry Breen in conducting these tests, and by E. James Koch in the statistical calculations.

[2] Culture No. 69, Catalogue and Registry of the Plant Viruses, American Type Culture Collection, 2029 M Street, N.W., Washington, D.C.

[3] The numbers assigned to the seed lots of Glacier barley used in these tests are those of R. F. Eslick, and indicate the same seed lots used in earlier tests by him (5) and by the author (3). Glacier No. 18 is known to carry virus in a high percentage of the seed, whereas Glacier No. 22 carries virus in a very small percentage of the seed. Since Glacier became infected naturally in field culture, there is no assurance that all of the seed came from virus-infected plants.

Table 1. Number of seedlings from virus-infected Glacier No. 18 barley expressing chlorotic markings on given days from seeding.

No. of days from seeding	Date seeded: June 16, 74° F a	June 16, 66° to 106° F b	June 16, 79° to 106° F c	Aug. 10, 65° F d	Aug. 12, 74° F e	Aug. 14, 80° F f	Aug. 7, 47° to 90° F g	Aug. 12, 95° to 101° F h
4	-	-	-	0	0	22	0	0
5	0	0	0	0	5	11	16	24
6	19	20	34	0	13	3	9	1
7	9	21	1	0	5	9	5	1
8	1	0	1	0	8	-	-	0
9	4	0	0	3	12	-	-	-
10	2	0	0	2	-	2	11	-
11	-	-	-	4	-	0	1	-
12	-	-	-	-	3	0	0	0
13	3	0	3	-	2	0	0	-
14	0	0	0	6	1	0	-	0
15	-	1	1	6	0	-	-	
16	1	0	0	-	0	-	-	
17	-	-	-	9	-	0	0	
18	-	-	-	2	-	-		
19	-	-	-	-	0	0		
20	0	0	1	0	-	-		
21	-	-	-	1	-	-		
23	-	-	-	1	-	-		
25	-	-	-	1	-	-		
28	0	0	0	-	-	-		
29				2	-	-		
32				8	-	-		
35				1	-	-		
37				2	0	0		
Symptom[1] ratings	2	3	4	1	2	4	4	2
Totals:								
Chlorotic	39	42	41	48	49	47	42	26
Healthy	10	7	8	12	7	9	9	4
All plants	49	49	49	60	56	56	51	30
Percent chlorotic	79.60	85.71	83.67	80.00	87.50	83.93	82.35	86.66

a, b, c, d, e, f and g grown in 4-inch pots, 1 seed per pot and seedlings not handled or in contact with others. a, d, e, and f grown in outdoor glass chambers at controlled temperatures indicated. Light reduced 18 to 20 percent by shading on bright days.

b -- grown in partly whitewashed glasshouse.

c --grown in glass chamber inside whitewashed glasshouse with the temperature controlled at 79° at night and on cool days, and reaching 106° on bright days.

g -- grown in the open, out-of-doors with full daylight.

h -- grown in 6-inch pots, 10 seedlings per pot, in a closed chamber with continuous light. One 40-Watt daylight tungsten and fluorescent light of 660 to 960 foot-candles, at the soil line.

i -- Ratings are based on the degree of chlorosis, and the extent of the chlorotic markings as follows: 1 = very mild light-green, gray or yellowish, one to few marks per leaf or seedling, first signs may appear early to late in a population; 4 = light-green or gray to yellow, and the most extensive on the leaves, appears early in the first leaf in most seedlings; 2 and 3 intergrade between 1 and 4.

The chlorotic markings consist of from one to many, slightly light green, gray or yellowish green dashes or short to long stripes running parallel to the veins of the leaf. These markings may occur at the tip, at the base, or throughout the leaf. In plants beyond the seedling stage, occasionally the markings are brown. Seedlings were examined daily when possible, as markings in the first two or three leaves tend to be stronger the first or second day of expression than later.

As a measure of seed-sampling error 100 10-seed samples were drawn from a mixture of 20 percent dyed and 80 percent non-dyed Glacier barley kernels. The ratio was chosen because about 80 percent of the kernels of Glacier No. 18 were infected with virus. The calculated standard error was 1.15. The least significant differences for five probability levels for the mean of five 10-seed samples are listed below.

Probability levels (Percent)	(L.S.D.)
20	0.66
10	0.86
5	1.10
1	1.35
0.1	1.75

In the final total counts of infected seedlings, differences between samples were too small for practical consideration. Conclusions regarding the relative effectiveness of culture methods are based on the intensity and the extent of the chlorotic markings and on the number of seedlings expressing symptoms soon after emergence.

Temperature and Light Effects

With the approach of spring, symptoms in seedlings, especially in young seedlings, became more pronounced, suggesting that warm temperatures and/or increased daylight favor the early expression and the intensity of the mild chlorotic markings in Glacier barley seedlings from virus-infected seed. Facilities did not permit simultaneous comparisons of close increments of constant temperatures and light, nor the study of temperatures controlled for day and night rhythms. However, the tests conducted with virus-infected Glacier barley show that warm to high temperatures and ample light favor the early expression of chlorotic markings in the first three leaves, especially in the first leaf, in from three to ten days from date of seeding. In tests conducted from about mid-June to mid-July, chlorotic markings could be observed, but they were weaker in seedlings grown in unobstructed daylight than they were in those grown in a whitewashed glasshouse or in glass-culture chambers, at warm to hot temperatures. In the tests conducted before and after this period, unobstructed daylight slightly favored the intensity of the expression of chlorotic markings, but more seedlings showed the markings very early in the first leaf when culture was under glass. During early April and early September unobstructed daylight still favored the early expression of the chlorotic markings, but cool temperatures (daily averages from 65° F downward) during these periods are likely to result in chlorotic patterns that tend to reduce color contrast in chlorotic markings induced by the virus. Sometimes these temperature-induced patterns can be confused with the virus-induced markings in virus-free plants.

The data from eight experiments are presented in Table 1. It will be observed that the intensity and extent of the chlorotic markings in seedlings grown at 80° F (column f) in a glass culture chamber during August was equal to that in seedlings growing out-of-doors in unobstructed daylight (column g), but a higher percentage of the seedlings showed signs by the fifth day from seeding at 80°. At 74° and 65° (columns e and d) there is a steady decline in the intensity of the markings and a lag and a scattering in the time of expression, characteristics that are undesirable in rapid and accurate indexing. The daily mean temperature out-of-doors (column g) was near 69°, yet the degree of expression and the extent of the chlorotic markings were rated the same as for the seedlings grown at nearly constant 80°. This suggests the possibility that warm daylight temperatures may be more important than equally warm night temperatures for the best chlorotic markings.

Inoculation tests for virus were made on leaf samples from each of the symptomless plants indicated in the columns of Table 1, on the dates indicated as follows: column c, July 17; a and b, July 27; e and f September 15. Each of the plants tested failed to give signs of virus. Early

in September, when the healthy plants were coming in head, samples of the flag leaves and of the roots were collected from one-half of the plants in each of the populations indicated in columns a, b, and c, and these were tested for virus. No signs of virus were detected in any of the samples. The 12 healthy plants in column d remained so after transfer to a warm greenhouse.

Continuous illumination from tungsten and fluorescent lamps (column h) favored the expression of chlorotic markings in a very high percentage of the first leaves on the fifth day from the date of seeding, when the temperature ranged from 95° to 101° F. These seedlings received no daylight, and although the intensity of the markings was less than in the seedlings grown with full daylight at 80° (column f), they could be diagnosed by an experienced observer. When this experiment was repeated at 79.5° to 81°, the degree of the chlorosis in the markings was slightly less than it was at the higher temperatures. Forty of the seedlings in this test were covered so as to receive a 17-hour daily photoperiod. The markings were slightly less intense in these seedlings than in the 40 seedlings receiving continuous illumination.

Other tests were conducted wholly with light from tungsten or fluorescent daylight type lamps, with illumination at the soil line of between 500 and 600 foot-candles, and at temperatures that ranged from 95° to 102° F.

The chlorotic markings were mild with both sources of light, but they appeared in the first leaf in a very high percentage of the seedlings. With continuous illumination from the tungsten source, the barley leaves were light green and flat, whereas with continuous fluorescent light the leaves were dark green and tended to roll, thus making diagnosis difficult. Part of the seedlings receiving fluorescent light were covered with light-proof cloth for 7 hours each day, giving a 17-hour photoperiod. The leaves of these plants did not roll, and they were essentially normal green in color. The chlorotic markings were stronger in these seedlings than in seedlings receiving continuous illumination, and equaled the markings in control seedlings receiving daylight only in a whitewashed glasshouse, with temperatures averaging 85.4° F during the period August 25 to September 6. The sun was exceptionally bright during this period.

To test the effectiveness of daylight of late summer, another test was started September 17 with Glacier No. 18 cultured under four sets of conditions as follows: 1) out-of-doors with full daylight, average daily temperature 62.5° F; 2) in a whitewashed glasshouse, average daily temperature 76.3°; 3) in a glass culture chamber with full daylight, at 80°; 4) in a glass culture chamber with full daylight, at 90°. There were 30 seedlings in each test, each seedling was grown singly in a 4-inch clay pot of soil.

In spite of the fact that the sky had a heavy overcast with no sun for two days following the emergence of the seedlings in sets 3 and 4 (80° and 90° F), symptoms appeared the fourth and the fifth days from seeding, in 80 percent and 73.33 percent of the first leaves in the two sets, respectively. In glasshouse set 2, symptoms appeared the fourth and fifth days from seeding in but 46.43 percent of the first leaves. The cooler temperatures delayed the seedlings in outdoor set 1, but there was bright sun after emergence. Symptoms appeared the fifth and sixth day from seeding in but 43.33 percent of the first leaves. In this set and in glasshouse set 2, the symptoms were so weak that most cases could be missed easily. In sets 3 and 4 at 80° and 90°, especially at 80°, the symptoms in the first leaves were strong enough for positive diagnosis. In the second leaf, there was little or no difference in the symptoms at the two temperatures, but in the third and fourth leaves, the symptoms were stronger at 90°, in spite of the fact that plants developed more shoots and longer leaves at 80°. In this test, the symptoms at 80° seemed to be slightly weaker than they were at the same temperature in the test of August 14 (Table 1, column f), when light intensity was much higher following emergence than was the case in the present test.

All symptomless seedlings were tested for virus on reaching the second and third-leaf stage on September 24. In each case, the entire seedling, including all of its washed roots, was used to prepare the inoculum, and this was used to inoculate 10 seedlings of Chevron barley. Table 2 gives the results of these tests. One of the healthy appearing seedlings from glasshouse set 2 was mildly infectious, and one of those from set 4 (90° F) was strongly infectious. All other symptomless seedlings in the test failed to induce infection in the test plants. It is of particular interest that virus was detectable in but one seedling in set 2, and in none of those in set 1.

Leaf samples of 86 symptomless plants from four other tests failed to show signs of virus in all but one test plant. This one expressed symptoms 15 days after it was tested and found to contain virus, which was 76 days after seeding. An untested plant expressed the first signs of

Table 2. Results of tests with Glacier No. 18 barley seeded September 17, and grown under the four conditions indicated.

Set no. and conditions of culture	Seedlings with signs Sept. 24	Seedlings no signs	Seedlings with signs	Seedlings with virus from assay	Total seedlings with virus
	No.	No.	Percent	No.	Percent
1 - Av. 62.5° F Out-of-doors	20	10	66.66	0	66.66
2 - Av. 76.3° F Whitewashed glasshouse	15	13	53.57	1	57.14
3 - 80° F Chamber	24	6	80.00	0	80.00
4 - 90° F Chamber	22	8	73.33	1	76.33

disease 43 days after seeding. These two plants, respectively, were from a glasshouse test and an out-of-door test conducted during the summer, in which early expression of symptoms occurred in very high percentages of the first leaves. It is very doubtful if contaminations folfowing seeding are involved, as these plants were grown singly in pots that were amply spaced and kept away from diseased plants. Very mild initial signs may have been overlooked early in the test, or the virus may have been very slow to multiply and invade the plants.

Tests were conducted under muslin shades in a whitewashed glasshouse during September to obtain information under very poor light conditions, as during prolonged periods of cloudiness, smoke, and fog. Light measurements in foot-candles were made with Weston light meter model 603, on a bright day, September 2, 10:00 A.M., E.S.T. Readings were made in the open between the glasshouses, in the whitewashed glasshouse, and under the muslin-covered frame shade in the whitewashed glasshouse. In each of the locations the photo-electric cell was directed at the zenith, but an additional reading was made in the open with the element directed at the sun. The readings are listed below:

Out-of-doors:
- Directly at sun..... 9030 F.C.
- Directly at zenith..... 8000

In whitewashed glasshouse, zenith:
- In area shaded by brace-bars..... 930
- In area shaded by whitewash only..... 3000
- Under muslin shade..... 210

With seedlings of Glacier No. 18 barley cultured under muslin the chlorotic markings were so faint that an inexperienced observer would not be likely to detect them in 90 percent of the cases. An experienced observer had to exercise care to detect signs in about 50 percent of the seedlings. The chlorotic markings in the same glasshouse but without a muslin shade were stronger, but at least 55 percent of the cases would not have been detected by an inexperienced observer. The seedlings grown out-of-doors with full daylight manifested the strongest degree of chlorosis, and not over 5 percent of the cases should escape an observer not familar with extremely mild chlorotic markings.

In tests conducted in a whitewashed glasshouse during bright weather late in August,

the expression of chlorotic markings seemed to be improved when the daily photoperiod (13 1/2 hours) was lengthened to 17 hours and to 24 hours by means of tungsten lamps (15 foot candles at the soil line). Differences were slight, but the markings seemed to be strongest in the seedlings receiving the 17-hour day.

When the pot tests with Glacier No. 18 barley were conducted out-of-doors through September, the expression of the chlorotic markings weakened and was delayed progressively in each succeeding test. When the daily temperature average was near 66° F and lower, a low-temperature chlorosis appeared in many of the first leaves. This confuses diagnosis of the symptoms induced by the virus. When such seedlings were transferred to 80° the low-temperature chlorosis disappeared rapidly, but virus symptoms in the first leaf showed little if any improvement. There was improvement in the expression of the markings in the second leaves, but this did not equal expression in the second leaves of the seedlings in the control maintained at 80° from the time of seeding.

Tests were conducted during the very short days of late December in two glass outdoor chambers kept at 80° F. In one chamber tungsten lamps of 25-watt capacity were arranged 10 inches apart in a square pattern 40 inches x 50 inches, 20 lamps in all. These provided 85 to 96 foot-candles of illumination at the soil line, which was 10 1/2 inches below the lamp filaments. This illumination was supplied during dark days to supplement the daylight, and during part of the night to lengthen the daily photoperiod to 15 1/2 hours. The other chamber received daylight only for 9 1/4 to 9 1/2 hours per day from sunrise to sunset. Six tests were conducted, with 50 seeds of Glacier No. 18 barley sown in each chamber in each test. During the tests the sky was cloudy or overcast much of the time, with bright sun about 10 percent of the time. Readings taken outside the chambers at 11:20 A.M. with the Weston Model No. 603 light meter directed at zenith ranged from 1600 to 4200 foot-candles. Readings taken at zenith in the culture chambers were 32 to 51 percent lower than the readings taken outside. The lamp and sash frames of the chambers excluded some light, but cinders from a nearby heating plant deposited on the glass accounted for most of the light reduction.

The percentages of seedlings showing signs of infection ranged from 77.5 to 87.2, with no significant difference between the percentages in the two chambers. These percentages are comparable with those obtained under the best conditions during the summer and autumn. The degree and the extent of the chlorotic markings in these tests were less than in tests in the same chambers with the summer sunlight. Augmenting poor daylight and lengthening the photoperiod with light from the tungsten source had little or no influence on the degree of expression of the chlorotic markings in these tests. An inexperienced observer is likely to overlook a greater number of infected seedlings under such reduced light conditions.

Other tests were conducted with young seedlings of Glacier No. 18 barley in glasshouses and glass chambers during early January at temperatures near 55°, 64°, 75°, and 80° F. Observations were discontinued after the development of the second leaf. At 55° and 60°, respectively, very mild chlorotic markings appeared in 9 percent and 3 percent of the seedlings; at 64° very mild markings appeared in 15 percent of the seedlings; and at 75° and 80°, respectively, markings were mild to moderate in 71 and 79 percent of the seedlings.

In previous reports the writer has stated that cool temperatures favor the expression of chlorotic markings in small grains infected with the type virus of barley stripe mosaic. This observation was based on comparisons between summer glasshouse temperatures that frequently went above 100° F, and winter glasshouse temperatures that fluctuate from 65° or 75°, at night and on cloudy days, to 90° on bright, warm days. When tests were conducted with barley and wheat in glass culture chambers held at nearly constant temperatures, it was found that the chlorotic markings differed very little in their intensity or in extent in the leaves during the first three weeks of growth at 70°, 75°, and 80°, though in the barley they seemed to be slightly the strongest at 80° when infection was from the seed. However, when infection was from manual inoculation, the markings in the barley and the wheat were slightly the strongest at 70° during the first two weeks, but by the third week differences were not apparent.

Similar results were obtained in tests with barley infected with the virus isolated from Glacier barley, and the chlorotic expression at 80° F was relatively more evident when infection was from the seed. In wheat infected with this virus by manual inoculation, the markings were slightly the strongest at 80° during the first two weeks, but differences were not apparent by the third week.

Constant temperatures in the range of 65° to 70° are more favorable to the development

of barley and wheat plants, and to the prolonged expression of virus symptoms, than are higher temperatures. However, it seems likely that a more complete understanding of this problem will come from tests at more natural fluctuating daily temperatures with mean temperatures adjusted to meet the changing requirements of the successive growth phases of the plant.

Glacier No. 18 barley seedlings were grown near 60° and 80° F in total darkness until the second leaves started to appear in the largest seedlings. Controls were grown at the same temperatures, but with daylight. Chlorotic markings appeared in the controls at 80°, but not in those at 60°, and no markings of any kind were detected in any of the yellow seedlings growing in darkness. However, when the latter were subjected to daylight at 80°, chlorotic markings were evident after 6 hours illumination, and they equaled those in the controls after a total of 14 hours illumination.

Inoculation tests indicated little if any difference between the yellow tissue produced in darkness and the green tissue produced in daylight with regard to virus activity in the shoot tissues at a given temperature. At both temperatures, virus was detected in two-thirds of the yellow shoots, but its activity was greater at 80° than at 60° F. Virus was present in the roots at 80°, but it was not detected in roots at 60° by the inoculation method used. These results suggest that the role of light in determining chlorotic markings lies chiefly in the development of chlorophyll or of some side effect, rather than in the production of virus in the shoot.

Observations on the Amount of Infection in Mass Samples of Seed and in Seeds From Infected Heads

In all tests with the virus-infected collections of Glacier barley seed, in which all of the seeds were produced by plants known to be infected, only part of each population gave evidence of being infected, when the seedling populations exceeded 25, and the seedlings did not make contact with each other. In a population of 28 seedlings of Glacier No. 18 grown at Beltsville, 92.86 percent of the seedlings gave evidence of being infected. This is the highest percentage yet obtained in any of the writer's tests with such a population. With smaller populations, infection occurs in all the seedlings of Glacier No. 18 occasionally. In sampling tests with a mixture composed of 20 percent dyed, and 80 percent non-dyed seeds, a population of 30 seeds containing 90 percent non-dyed seeds was drawn only twice in 66 samplings.

With the type virus of barley stripe mosaic (false stripe), seedling infection rarely reached 80 percent from seed from known infected plants of Chevron barley. When heads of Chevron barley were still in the flag sheath, the primary shoots were inoculated by wiping the leaves. In some instances, the heads were killed, whereas others produced mature seeds. With plants inoculated in the seedling stage and with those inoculated in the boot-stage, evidence of virus has not been observed to exceed 80 percent of the seed in well- and moderately well-filled heads, but it has sometimes reached 100 percent in very poorly-filled heads. With inoculation in the late boot stage, seed infection has tended to decrease. Infected seeds tend to be distributed at random in the heads, though in some heads they may be in localized groups anywhere along the rachis. No such localization has been observed in any given kernel row. Culture was out-of-doors from March to July.

Spread of Virus from Diseased to Healthy Barley Plants by Contact and Handling

Five seeds each of Glacier No. 18 (infected) and of Glacier No. 22 ("non-infected") were sown alternately in a circle in each of 20 6-inch pots in a whitewashed glasshouse on July 23, 1953, when the temperature averaged about 84° F. Five pots of Glacier No. 22 only were sown for a control. The plants in 10 of the pots of mixed seedings were not touched during the experiment, whereas those in the remaining 10 pots were handled carefully seven times during 34 days while making diagnoses. The glasshouse ventilators were open during the test, and usually there was sufficient air movement to cause rubbing contact of the foliage of the seedlings within a set, but the two sets were separated. The data in Table 3 show that no chlorotic markings appeared in the Glacier No. 22 control, and that handling the plants in the mixed seeding increased the spread of infection to Glacier No. 22 and permitted fewer seedlings of Glacier No. 18 to escape infection. The latter showed chlorotic markings in the first leaf of the majority of the infected seedlings by the eighth day from seeding.

Other tests were set up to determine the effect of handling without contact between infected

and healthy seedlings. Seeds of Glacier No. 18 and No. 22 were sown singly in 4-inch clay pots in the glasshouse with the pots spaced to prevent plant contacts. On the sixth day after seeding, and when chlorotic markings were evident in Glacier No. 18, the seedlings were carefully handled, alternating from diseased to healthy. Such handling was repeated 14 times over a period of 21 days, and one seedling of Glacier No. 22 out of 9 developed symptoms after the 13th handling. After the 14th handling, the method was changed, by alternately drawing a diseased leaf and a leaf of a healthy plant between the thumb and index finger, with pressure. This was done with at least one leaf on each shoot of each healthy plant, on each of 23 days over a period of 37 days. Three of the 8 remaining plants of Glacier No. 22 developed chlorotic markings following the 16th, 21st, and 23rd handling, respectively. Control plants of Glacier No. 22 that were not handled remained free of chlorotic markings.

Table 3. Spread of infection from Glacier No. 18 seedlings to Glacier No. 22 seedlings in mixed seedings.

Days from seeding	Number of seedlings showing chlorotic markings				
	Mixed seeding of Glacier No. 18 and No. 22				Glacier No. 22 not handled
	Seedlings not handled		Seedlings handled 7 times		
	Gl. 18	Gl. 22	Gl. 18	Gl. 22	
No.	No.	No.	No.	No.	No.
7	17	1[a]	11	0	0
8	12	0	20	0	0
12	3	0	3	2	0
14	1	2	3	1	0
15	0	3	0	4	0
19	1	5	2	8	0
26	3	7	5	17	0
34	1	3	1	8	0
48	4	7	1	9	0
Totals:					
Chlorotic	42	27	46	49	0
Healthy	6	22	1	0	50
All plants	48	49	47	49	50
Percent chlorotic	87.50	55.10	97.87	100.00	0

[a] This seedling was infected from its seed, and was deducted from the totals.

Many infected seedlings show a rather high concentration of virus in the roots and leaves beginning with early germination and continuing throughout the life of the plants. Tests were conducted to get information on the transmission of virus by both leaf and root contacts. Seeds of Glacier No. 18 (infected) and Glacier No. 22 ("non-infected") were sown in paired rows 1 inch apart and 24 inches long in soil in wooden boxes in a whitewashed glasshouse on August 19 when the average daily temperature was near 82° F. In set 1 the roots of the two rows were separated by root-proof partitions, but the leaves were allowed to contact freely in a location in which there was little air movement. In set 2 the leaves also were separated by glass partitions. In sets 3 and 4, the roots of the two rows intermingled freely, but the leaves were separated. In set 4 the roots were cut by drawing a knife through the soil between the rows when the seedlings had three leaves. Great care was exercised during watering to avoid contact with the plants. Observers washed their hands with soap and water after examining each row to avoid the spreading of infection by handling leaves. The few seedlings of Glacier No. 22 showing evidence of infected embryos were removed immediately.

Table 4. Transmission of virus from infected Glacier No. 18 to healthy Glacier No. 22 barley by contact. Data recorded the 58th day and the 77th day from seeding, August 19 to October 16, to November 4.

Set No.	Treatment[a]	Plants developing chlorotic markings over the total number of plants			
		Glacier No. 18		Glacier No. 22	
		58 days	77 days	58 days	77 days
1	Roots isolated; leaves not	22/22	22/22	1/22	20/20
2	Roots isolated; leaves isolated	18/22	22/22	0/23	2/23
3	Roots not isolated; leaves isolated	21/22	22/22	0/22	22/22
4	Roots not isolated, but cut; leaves isolated	14/20	20/20	0/22	3/22

[a] After the 58th day from seeding the glass partitions were removed from sets 2, 3, and 4 to allow the leaves of the infected and healthy plants to intermingle. Sets 1 and 3 were placed between two oscillating electric fans.

The data in Table 4 indicate no transmission of virus from diseased to healthy plants through root contact and little or none through leaf contact in the absence of appreciable air movement. On the fifty-eighth day after seeding the glass partitions were removed from sets, 2, 3, and 4 to allow free contact of the foliage. Sets 1 and 3 were placed between two oscillating electric fans which operated each day from 8:00 A.M. to 4:00 P.M., and the boxes were reversed each morning.

The leaf movements and contacts were about equal to those occurring in a field during a moderate wind. Sets 2 and 4 were placed nearby where the air was still. Data taken 19 days later show that brisk air movement which increases foliage contacts, and probably causes slight tissue bruising, favors the spread of infection from infected to healthy plants.

In other tests Glacier No. 22 seedlings did not become infected when the rinsed roots were inoculated with fresh virus-laden juice by the carborundum-rubbing method or by rubbing the roots with the inoculum without carborundum. Rubbing the rinsed roots with rinsed virus-infected roots of diseased seedlings also failed to produce infection. Assays failed to reveal virus in the inoculated roots of these plants although the juice and the infected roots that were used for inoculum were highly active.

It appears that most of the accidental infection of healthy Glacier plants in mixed seedings with infected plants under glasshouse culture resulted from harsh contacts of leaves through rough handling or brisk movement of air that caused some abrasion of the leaf tissues.

The Use of Water for Cleansing the Hands of Virus

Seedlings of Atsel barley, which give a strong reaction, were inoculated with the virus from Glacier barley. A thick pad of cotton gauze was saturated with fresh virus extract from barley leaves and the thumb and index finger were pressed into this pad to pick up the virus for inoculating each seedling. In inoculating, each leaf was drawn between the thumb and finger. All of the 15 seedlings thus inoculated developed typical symptoms. The same number of seedlings was processed in the manner just described, except that the thumb and finger were washed in a 320 ml supply of tap water and wiped on a towel after each contact with the pad of virus before drawing the leaves between the thumb and finger. None of these seedlings developed symptoms

of virus.

These results indicate that there is little chance of spreading virus infection if the hands are washed in water and then wiped after handling infected plants.

Hot-water Treatment of Infected Seed

Lots of 36 dry seeds of Glacier No. 18 barley were submerged in gauze bags in a water bath for 13 minutes at 55°, 57°, and 59° C. The seeds were then cooled at room temperature, planted immediately in soil, and cultured at 26.7° C (80° F). In the unheated control, 24 out of 35 or 69 percent of the seedlings were infected; with the 55° and the 57° treatments, 17 out of 24 (71 percent), and 1 out of 1 (100 percent) of the seedlings respectively, were infected. Seeds heated at 59° C did not germinate. It appears that neither the virus nor the infected embryos can be killed at temperatures lower than those that will kill the healthy embryos.

DISCUSSION AND RECOMMENDATIONS

Tests with virus-infected seed of Glacier barley have shown that essentially constant temperatures of 75° to 100° F with adequate light favor the expression of the characteristic mildly and moderately chlorotic markings in the first three leaves of the seedlings. We have adopted 80° for routine seed testing.

When seedlings were spaced to prevent plant to plant contacts through the leaves there was always a residual population that expressed no symptoms, and inoculation tests have detected latent virus in less than 2 percent of these.

Furthermore, tests with the type virus of stripe mosaic (false stripe) indicate that virus either does not enter all the embryos in most infected heads or it is of a concentration too low to infect some of the subsequent seedlings sufficiently to be detected by our inoculation method. When the symptomless plants are to be propagated for seed they should be transferred as soon as possible to the cooler temperatures and light conditions that favor growth and seed production.

When virus-infected seed is being tested in a greenhouse during the winter, it may be necessary to augment daylight with electric light on dark days. The intensity, quality, and daily duration of supplemental light for best results have not been determined. When the testing is done entirely under incandescent light the seedlings showing no chlorotic markings should be re-examined in daylight.

Tests under glasshouse conditions suggest that testing out-of-doors during the autumn and possibly during the winter might best be done in southern Arizona or California where light, temperatures, and low rainfall conditions favor the development and recording of virus symptoms and the growth and maturity of healthy winter and spring barley varieites. However, even there glasshouse culture might be preferable during late autumn and winter in order to maintain higher average temperatures.

Testing spring barleys out-of-doors during the spring should be timed to give ample opportunity for the healthy plants to mature. In the Central Valley of California, as at Davis, summer conditions may favor testing spring varieties, and for the late culture of the healthy plants. However, very high day temperatures make for low yields of seed. In the spring-barley areas the temperatures may average too low and glasshouse culture may be more dependable for detecting the infected seedlings, especially during periods of sub-normal temperature. On the other hand, a study based on regulated daily fluctuating temperatures may show that the daily mean temperatures which favor testing may be considerably lower than 80° F. Constant night temperatures of 80° and above, such as obtained in the present studies, are quite beyond those to which barley is adapted.

Testing small seedlings in field plots and soil beds is exceedingly tedious even in fair weather. It is practically impossible to make critical observations in the field during bad weather. The experience at Beltsville indicates that the seedlings should be grown in clay pots, 6-inch or 8-inch sizes for mass seedings of 10 and 14 seedlings per pot, respectively, and 4-inch size for single seedlings. The pots should be placed on benches for convenience in recording symptoms.

Since virus transmission by plant to plant contact or rough handling must be guarded against, and many samples of barley seed are likely to be free of virus, a two-step system of testing or indexing is suggested. Mass seeding may be made in pots or elsewhere, with the

seeds spaced 1 1/2 to 2 inches apart in a circle or row. Seed lots showing no chlorotic markings may be retested in the same manner before concluding that they are free from virus. The disease-free seedlings from seed lots showing 20 or 30 percent of diseased seedlings may be saved for propagation if all diseased seedlings are removed immediately while they are small. After the second leaf appears, the seedlings adjacent to diseased seedlings also should be removed. Seed lots having a higher percentage of infected seedlings should be retested with a wide spacing of the seed in rows, or with single seeds in 4-inch pots or in other suitable containers spaced sufficiently to prevent inter-plant contacts.

Infected seedlings should be discarded when first observed. The healthy seedlings should be transplanted to the field or other suitable location, be properly spaced, and possibly staked, to prevent inter-plant contacts through wind whipping, and they should be observed closely and regularly for delayed chlorotic markings. All plants developing late signs should be dug up, using a trowel or shovel to avoid contact with healthy plants. The same care should be exercised while roguing experimental plots and fields. However, in this case all plants that may have made contact with diseased plants should also be removed, and be deposited where they are not an infection-hazard to the healthy plants. After handling infected plants washing the hands in a pail of water followed by wiping on a towel before handling healthy plants is regarded as a safe procedure.

Detecting traces of infected seed in samples is difficult. To detect them when they occur at the rate of 1.562 percent of the population, within the limits of the 0.1 percent level of probability, 442 seedlings must be tested.

For equal assurance, 107 seedlings must be tested to detect infection in 6.25 percent of the population. Close field inspection and careful roguing appears to be the best way to detect the trace infections.

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RESULTS FROM STUDIES OF ENTRIES IN THE UNIFORM BARLEY POWDERY MILDEW NURSERIES

J. G. Moseman

Powdery mildew, Erysiphe graminis var. hordei El. Marchal, is an almost omnipresent pathogen of barley. It has caused considerable losses in parts of Europe, Asia, and the Middle East. In North America, it is one of the more important diseases in the winter barley growing areas of eastern United States. In the spring barley area, particularly in California and British Columbia, it causes losses almost every year. It is seldom severe in the drier Great Plains region, but damage often occurs near the Great Lakes.

The losses resulting from powdery mildew are not so spectacular as those from some other diseases. Powdery mildew rarely develops in epidemic proportions but reduction in plant vigor, grain quality, and production may be appreciable.

Results of the studies made on the entries in the Uniform Spring Barley Mildew Nursery for 1951 and 1952 and the Uniform Winter Barley Nursery in 1952-53 are included in this report. The spring barley nursery was sown at 14 locations in 1951 and at 13 locations in 1952. The winter barley nursery was sown at 12 locations. All entries in both nurseries were tested in the greenhouse in the seedling stage to 5 physiological races of powdery mildew at Raleigh, North Carolina.

Material and Methods

Most of the varieties used in these studies were selected from the World Collection of barley maintained by the Section of Cereal Crops and Diseases. The author wishes to express his appreciation to D. J. Ward and G. A. Wiebe for making this seed available. The following persons furnished entries for the spring barley nurseries: D. C. Huntley, D. G. Hamilton, R. G. Shands, and K. J. Frey. J. M. Poehlman, D. A. Reid, E. S. McFadden, T. H. Johnston, and N. F. Jensen supplied entries for the winter barley nursery.

Each cooperator received 5 grams of seed of each entry for sowing in their barley nursery. Readings were made when the disease was most evident, in most cases on the basis of the percentage of leaf area covered by the fungus. At Agassiz, British Columbia, Mr. Atkinson harvested seed of each entry, when the level of infection was extremely low. The varieties were then inoculated in the seedling stage with a local collection of mildew.

During the past two years the writer has isolated several races of powdery mildew from perithecia on leaves of plants sent to him, and in addition, has maintained several races obtained from plants that he collected himself. The cultures used in this study were obtained from the following sources:

Race 9 -- conidial culture collected by J. G. Moseman at Statesville, North Carolina.
Race 3 -- perithecial culture collected by D. K. Taylor at Agassiz, British Columbia, Canada.
Race 4 -- perithecial culture collected by G. W. Rivers at Beesville, Texas.
Race 11 -- perithecial culture collected by J. G. Moseman at Blacksburg, Virginia.
Race 8 -- perithecial culture collected by D. G. Hamilton at Ottawa, Ontario, Canada.

Each culture used in these studies originated from a single pustule. The cultures were maintained on plants of the Heil Hanna #3 variety (C. I. 682) grown in 250 x 29 mm. test tubes plugged with cotton. The cultures were increased by transferring spores from plants in the tubes to plants growing in 4-inch clay pots surrounded by a glass lamp chimney or a plastic sun-ray cylinder the top of which was covered with at least four layers of cheesecloth. The plants were watered by allowing water to run down the side of the chimney or cylinder. This minimized contamination with other races. The seedlings of the varieties in the mildew nurseries were grown in 3-inch clay pots on a greenhouse bench in a section free from mildew where the temperature was maintained at approximately 70° F. The seedlings were covered with a transparent plastic cloth until they were inoculated. The plants were inoculated a week to ten days following planting, by shaking infected plants over the top of the bench on which the inoculated

Table 1. Reaction of varieties in the 1951 and 1952 Uniform Spring Barley Powdery Mildew Nursery to Erysiphe graminis var. hordei at five locations and to physiological races in the seedling stage.

C.I. P.I. No.	Variety or selection	Reaction in[a]										
		Field 1951			Field 1952:		Seedling Stage					
		Wisconsin	Ottawa	New York	British Columbia	Guelph	R 9	R 3	R 4	R 11	R 8	B.C.
	Heines Haha, Germany	-	-	-	10	5	2	3	1	2	3-4	-
	Franken II, Germany	-	-	-	0	0	1	1	0	0	0	-
	Vogels Wein, Germany	-	-	-	5	10	2-3	2	0	2	0	-
	4666-5, Vantage x C.I. 4979	-	-	-	0	0	0-1	0-1	0	1	0	-
	4666-22, Vantage x C.I. 4979	-	-	-	0	10	1	0	0	0-1	0-1	-
	4674-24, Anoidium x C.I. 4979	-	-	-	0	50	1	0	1	1	0	-
	4805-19, (Velvet-Olli x OAC 21) x C.I. 1257	-			0	0	0,2	4	0,2	0-1	0	-
9185	4111-87 H42, Wisconsin	-	-	-	10	25	1-4	0	1	4	0	-
9190	X330-5 R144, Wisconsin	-	-	-	60	80	4	4	4	4	4	-
9191	X379-3 R148, Wisconsin	-	-	-	40	15	4	4	4	4	4	-
	M 49001, Michigan	-	-	-	0	0	1	0	0	0	0-1	-
906	Hanna	-	-	-	0	5	1	1	0-1	0-1	1	-
1016	Kwan	0	0	90	10	5	2	4	2	1-2	1	1-2
1017	Monte Cristo	0	5	85	0	tr.	0-1	0-1	0-1	0	0-1	0
2433	Duplex	0	0	0	0	tr.	2-3	1	1	1	1	0
3400	Mianwali	0	0	20	0	0	0-1	0-1	0	0-1	0	0
3401	Multan	0	0	60	0	0	0-1	0-1	0	0-1	0-1	0-1
3609	Palmella Blue	0	0	0	0	0	1	0	1	1	1	1
4343-1	Spiti	0	0	25	0	0	0	0-1	0-1	0	0	0
4355	Rupee	0	0	15	0	0	0	0	0-1	0	0	0
4979	Rabat	0	0	0	0	0	1	0	0	0-1	0-1	0
5862	Menelik	3	15	90	10	tr.	1	1	1	0-1	0-1	0-1
6193	Cebaba Capa	10	15	95	20	0	1	0-1	1-4	2	1-2	3-4
7323	Atlas 46	0	0	20	tr.	0	1	1	0-1	0	1	0-1
8051	Stephan	0	0	tr.	0	0	1	1	0	0-1	0	0-1
3933	Vagabond	0	0	50	-	-	0-1	1	0	0-1	0	0-1
4219	-----	tr.	5	95	-	-	1	1	1	0-1	0	0-1
4220-1	-----	2	10	90	-	-	1	1	1	0-1	1	0-1
4356	-----	tr.	0	0	-	-	0	1	1	2	0-1	1
4974	-----	0	15	10	-	-	1	4	1-2	2	0	3-4
6168	Long Glumes	0	0	0	--	-	1	0-1	1	0-1	0	0-1
666	Black Hullness	t	60	5-10	20	15	1	3-4	4	4	4	4,2-3
1111	Chevron	1	10	0	0	20	4	1	1	4	3	0
928	Goldfoil	0	0	tr.	10	tr.	0-1	0	0-1	0	0	0-1
682	Heil's Hanna	25	75	tr.	60	25	4	4	4	4	4	3
595	Nepal	5	15	95	40	80	1-2	4	4	4	4	1
935	Peruvian	2	15	95	80	70	1-2	4	1-2	4	2	4

[a] Readings in field give percent of leaf area covered by the fungus. Readings in the greenhouse were: 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, 4 = very susceptible, and 1-4 = mesothetic.

Table 2. Reaction of varieties in the 1952-53 Uniform Winter Barley Powdery Mildew Nursery to Erysiphe graminis var. hordei at Blacksburg, Va., and Knoxville, Tenn., and to five physiological races in the seedling stage.

C.I. P.I. No.	Variety or selection	Reaction in[a]						
		Field		Seedling Stage				
		Va.	Tenn.	Race 9	Race 3	Race 4	Race 11	Race 8
704	Popeline, Caucasus	0	R	22	1	1	1-2	1
1179	Algerian, Algiers	0	R	1	0-1	0-1	1	0
2483	Modia, North Africa	0	R	1	0-1	1	0-1	1
4968	- , Iraq	0	R	0-1	0-1	1	1	1
5000	- , Iraq	0	R	1-2	2	1-2	1-2	2
6305	Psaknon, Australia	0	R	1-2	1-2	1-2	0-1	1-2
6306	Ricardo, Uruquay	0	R	1	0-1	1	1	1
6980	Lion x Minia, Hybrid	25	R	2	4	2	4	1-2
7381	Miyagi No. 12, Japan	5	R	2	1-2	1-2	2	3-4
7573	C.C. Sel. C.I. 6625	0	R	1-2	1	1-2	2,4	1
180668	1281/48, Germany	0	R	1-2	0	0	0	0-1
180669	1290/48, Germany	0	R	1	1	0-1	0	0-1
183371	Aizu 4, Japan	0	R	1-2	1	1-2	2	-
7854	- , Turkey	5	R	1,4	1,4	1,4	1,4	3
9168	B575 Admire-MEB	50	CS	4	4	4	4	4
7568	Mo. B-400	25	CS	1-4	1-2	2	4	1-2
7574	Kenbar	0	R	1	0	1	1-2	1
8099	Goliad	25	R	4	4	4	4	4
5529	Dicktoo	25	S	3	1	1-4	1-4	1
7580	Kearney	10	CS	3	1-4	4	1-4	2
7524	Harbine	40	CS	4	4	4	4	4
9174	Okla. 1005 Sel.	0	CS	1	1	0	0-1	0-1
5238	Dobaku	25	S	1-4	1-4	2	2-3	2
8067	Hudson	0	CS	4	4	4	4	4
6728	Wong	0	CS	4	4	4	4	4
----	N.Y. Sel. 563A-13-11-10	0	R	4	1	4	4	2
5644	Caspian	0	R	1-4	1	0-1	2	1
666	Black Hulless	0	R	1	3-4	4	4	4
1111	Chevron	10	R	4	1	1	4	3
928	Goldfoil	0	R	0-1	0	0-1	0	0
682	Heil's Hanna	40	CS	4	4	4	4	4
595	Nepal	0	R	1-2	4	4	4	4
935	Peruvian	25	R	1-2	4	1-2	4	2

[a] Readings at Blacksburg, Va., were: 0 to 50 (resistant to susceptible). Readings at Knoxville, Tenn., were: CS = completely susceptible, S = susceptible, R = resistant. Readings in greenhouse were: 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, 4 = very susceptible, and 1-4 = mesothetic.

plants were growing. At the time of inoculation, plants were fertilized with a nutrient solution high in nitrogen. It was found that infection took place on plants without free water as well as on plants with free water on the leaves. The plants usually were sprayed with water to increase adherence of spores. Readings were taken seven to ten days and again about two weeks following inoculation. Usually the plants were inoculated two or three times at two day intervals. This assured a uniform inoculation and reduced the position effect on the bench.

Results

Readings made on the Uniform Spring Barley Mildew Nursery are given in Table 1. R. G. Shands at Madison, Wisconsin, D. G. Hamilton at Ottawa, Ontario, Canada, and N. F. Jensen at Ithaca, New York, obtained readings in 1951. In 1952, D. K. Taylor at Agassiz, British Columbia, Canada, and D. N. Huntley at Guelph, Ontario, Canada, made readings on the nursery. Other cooperators in the spring barley area sent mildew-infected plants from their nurseries. Many reported that since most of the entries in the uniform nursery were resistant mildew did not build up sufficiently in that area of the nursery to permit the taking of readings. Four varieties in those nurseries are omitted from Table 1. Of these, Algerian, Modia, and Ricardo had zero readings in the field and Psaknon had only 2 percent mildew at Ithaca in 1951. Their reaction in the seedling stage to the various physiological races of mildew is given in Table 2.

Several entries in the Uniform Spring Barley Mildew Nursery were resistant in all field and greenhouse tests. Franken II was the most resistant of the three introductions from Germany supplied by D. C. Huntley. Of the three selections from crosses involving Rabat, C. I. 4979, supplied by D. G. Hamilton, selection 4666-5 was resistant in all tests and the other two had some mildew in the nursery at Guelph. The cross involving Bolivia, C. I. 1257, possessed excellent field resistance but segregated for resistance in the seedling stage. This could have been anticipated, since Bolivia is susceptible to most races in the seedling stage. Selection M-49001, supplied by K. J. Frey, was resistant in all tests. Other entries that were resistant in all field and greenhouse tests were: Goldfoil, Hanna, Palmella Blue, Rabat, Stephan, and Long Glumes. Goldfoil, Stephan, and Hanna are susceptible to the new race of mildew found in California by C. W. Schaller[1]. The three entries from Wisconsin supplied by R. G. Shands were susceptible in most tests, but C. I. 9185 showed resistance to certain races in the seedling stage. These three entries were highly resistant to stem rust (Puccinia graminis) at Guelph and the first two were resistant to leaf rust (P. hordei) there.

Readings were obtained on the Uniform Winter Barley Mildew Nursery at Blacksburg, Virginia by C. W. Roane and at Knoxville, Tennessee by N. I. Hancock, in 1952-53. Several varieties were killed by the severe winter weather at the more northern locations in the winter barley growing region.

Entries in the winter barley nursery that were resistant in all the tests were: Algerian, Modia, C. I. 4968, Psaknon, Ricardo, P. I. 180668, P. I. 180669, Kenbar, and Goldfoil. C. I. 9174, which was resistant to mildew in the field at Blacksburg and highly resistant to all races in the seedling stage, was completely susceptible at Knoxville. Race 6 was the predominant race at Knoxville according to the reaction of the six different varieties listed in Table 2. Races 6, 9, and a new race to which Chevron, Heil's Hanna, and Peruvian are susceptible, were obtained from conidial cultures from plants in the nursery at Blacksburg.

COOPERATIVE INVESTIGATIONS BETWEEN THE FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND THE NORTH CAROLINA STATE AGRICULTURAL EXPERIMENT STATION.

[1] Unpublished data supplied by Dr. C. W. Schaller.

DISEASES OF SMALL GRAINS IN TEXAS IN 1953

M. C. Futrell and I. M. Atkins

Several unusual disease developments in the small grain crop in Texas in 1953 are worth recording. The crop season was one of great extremes resulting in a near failure over the majority of the wheat-producing areas, with a bumper crop in other areas. Extreme drought has persisted in the major wheat-producing area of West Texas for three years. Total wheat production in Texas in 1953 was 23,035,000 bushels compared to the ten-year average of 59,088,000 bushels. By contrast conditions were, for the most part, favorable for oats, which are largely grown in Central Texas. The estimated crop (December) of 39,150,000 bushels was considerably above the ten-year average of 25,280,000 bushels.

OAT DISEASES

Oat diseases were not especially destructive in 1953 since record yields of high-quality forage and grain were reported throughout the oat-producing area of Texas. Crown rust (Puccinia coronata), usually one of the most damaging diseases of oats in Texas, was found in localized infection centers in South Texas between March 15 and April 1. The original infections in this area occurred after a period of strong east winds. The fungus spread from these areas but never reached epidemic proportions in the main oat-producing areas of Central Texas. The overwintering and northward spread of crown rust in Texas is increased by the presence of volunteer oat plants along the roadsides. The volunteer oats consist of wild oats and of false wild and Red Rustproof types that have escaped cultivation. In a number of cases early field infections could be traced to wild oat plants growing along the side of the road adjacent to the field. Race 101 of crown rust apparently has not gained a foothold in the State since varieties carrying the Victoria resistance were not rusted under field conditions this year.

Stem rust (Puccinia graminis var. avenae) was of minor importance and caused little reduction in the yield of oats except in isolated localities of the Beeville area. Races 2, 5, 7, and 8 have been obtained from Texas collections by the rust laboratory at St. Paul, Minnesota, to date, which confirms the observations on the field reaction of varieties. At Denton, the Canadian strains R. L. 1692-2-7 and R. L. 2105 from the cross R. L. 1574 x Roxton had about 10 percent of their stem area covered with susceptible type pustules, while a sister strain, R. L. 2114 remained resistant under these conditions. Rust specimens were sent in for special race identification tests. Other lines having the Hajira-Joanette resistance showed no susceptibility.

Moderate to high smut infection of oats occurred in some fields in the State. Apparently both Ustilago avenae and U. kolleri were present.

The oat acreage used for pasture in South Texas has been increasing rapidly during the past ten years, and in some areas the crop has been grown on the same land for a number of years. Blights caused by Helminthosporium victoriae and Pyrenophora avenae are becoming prevalent in these fields, and Septoria species were isolated from some blighted plants. The blights did not occur farther north and very little damage resulted in the major commercial areas of Texas this year.

WHEAT DISEASES

McFadden[1] reported stripe rust, caused by Puccinia glumarum var. tritici, occurring on wheat at College Station, in the spring of 1941. One infection center of stripe rust was found on winter wheat at Denton this year. Temperatures became unfavorable immediately after discovery and there was no additional spread of the organism. The fungus was identified by Dr. Wayne Bever, U. S. Department of Agriculture, Urbana, Illinois.

The overall damage caused by stem rust (P. graminis var. tritici) was small; however, urediospores were produced profusely, resulting in heavy northward movement of the fungus. The winter was mild and stem rust could have overwintered in Texas, but moisture in most areas during the fall and winter months was a limiting factor, and no stem rust infections were found during a survey of wheat fields in the San Antonio area on February 27. The first shower of urediospores apparently occurred over the South Texas area sometime during the middle of March as stem rust was found at Beeville, Weslaco, Crystal City, and San Antonio during the

[1] McFadden, E. S. Unpublished data, U. S. Dept. Agr., Department of Agronomy, Texas Agricultural Experiment Station, College Station, Texas.

latter part of the month.

Stem rust developed very rapidly in South Texas during the period from April 15 to May 1, and for a time threatened serious losses to the wheat area of Central Texas. The West Texas area was so dry that only traces of the disease developed. According to the reaction of varieties infected and to preliminary reports on race identification, race 15B of wheat stem rust appeared to be widely distributed. Varieties such as Lee (C. I. 12488), Supremo (C. I. 12531), and many of the durum wheats were infected in the nurseries at College Station and at the Prairie View Substation. Other races reported to date for the Texas area by the Rust Laboratory at St. Paul include 11, 17, 49,56, and 139. Environmental conditions characterized by clear, hot, dry weather and other limiting factors from May 16 through maturity checked stem rust development, and losses to the wheat crop were light. A considerable amount of inoculum built up in the North Central Texas area and late fields were damaged, with biotypes of the pathogen present that were very virulent on Red May (C. I. 5336) and derivatives of this variety.

The prevalence of leaf rust (P. rubigo-vera var. tritici), was the lowest in 20 years. Infection centers were found at College Station, February 12, and in a field of Comanche (C. I. 11673) wheat near Richland Springs, February 28. The organism probably overwintered at Richland Springs as this local area had heavy rains during the fall. Infection could have occurred at College Station any time after the grain emerged in November. Infections were prevalent in the Beeville area after March 15. The spread of the fungus from these areas was slow with little damage resulting to the commercial crop, and no information was obtained on the leaf rust reaction of experimental strains except in the nurseries at Beeville and College Station.

Powdery mildew (Erysiphe graminis var. tritici) was widespread through the North Central Texas wheat-producing area in early May but probably did not reduce yields greatly. Bunt (Tilletia spp.) occurred in a number of wheatfields, with some showing 15 or 20 percent infection. Loose smut (Ustilago tritici), like leaf rust, was conspicuous by its absence even in mixed fields of Mediterranean wheat. Other diseases observed included some damage by a complex of foot and root rots to some 15,000 acres of wheat in the Rolling Plains area.

A disorder of wheat present in the Dallas-Sherman area caused great concern for a time. No adequate diagnosis of its pathologic or physiologic nature was evolved although specimens were sent to a number of specialists. Entire fields or parts of fields of wheat became yellowed and stunted, with the leaf tissue often turning red and later necrotic. From a distance the plants appeared to be covered with leaf rust although leaf rust was not seen in the area at the time and in most fields not more than a trace ever developed. None of the common foot and root rot symptoms could be found upon examination of the roots and growing point. The Quanah (C. I. 12145) variety was especially susceptible to this disorder, and the disease or condition was most severe where Quanah had been grown on the same land for two or more years. Pathologists familiar with mosaic did not consider the disorder to be typical of any known mosaics. As the growing conditions improved, the crop appeared to recover in many instances, but in others there was a reduction in yield.

BARLEY DISEASES

Several barley diseases were more damaging than usual in Texas, probably because of the excellent early rank growth which permitted diseases to develop profusely. Bacterial blight (Xanthomonas translucens) was prevalent in the nursery at Denton and moderate damage occurred on the susceptible varieties Arivat 18 (C. I. 6573), Harlan (C. I. 7008), and Atlas (C. I. 4118), Kindred (C. I. 6969), Montcalm (C. I. 7149), and Otis showed varying degrees of resistance. Powdery mildew (E. graminis var. hordei) was abundant in the Denton area. Both net blotch (Pyrenophora teres) and spot blotch (Helminthosporium sativum) were prevalent in South Texas during the late winter and early spring; Goliad C. I. 5371), however, remained relatively free of infection. Barley leaf rust (P. hordei) was present in local areas but, like the leaf rusts of other cereals, its spread was limited. Barley stripe mosaic or false stripe, a virus disease, was present on experimental varieties at Denton. Marked differences in infection between varieties were observed, but since this virus is seed-borne, it is questionable how much confidence can be attached to such observations. Among the varieties that were heavily infected were Tennessee Winter (C. I. 3543), Fayette (C. I. 245), and Pueblo (C. I. 8070).

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE AND THE TEXAS AGRICULTURAL EXPERIMENT STATION, COLLEGE STATION, TEXAS

CO-OPERATIVE SEED TREATMENT TRIALS - 1953[1]

J. E. Machacek[2]

FIELD TRIALS

Thirty seed treatments were compared in these trials during 1953. They included a dry-seed control, 11 treatments which had not been in previously, 2 treatments which were being re-tested because their ability to control smut was questioned, and 16 treatments which, while on the market in Canada for a year or more, had not previously been tested together. These treatments were applied to naturally contaminated, infested, or bruised seed, and were tested against bunt of wheat (almost entirely Tilletia foetida (Wallr.) Liro), smut of oats (82 percent Ustilago avenae (Pers.) Rostr. and 18 percent U. kolleri Wille), smut of barley (96 percent U. nigra Tapke and 3.7 percent U. nuda (Jens.) Rostr.), seedling-blight of wheat (Helminthosporium sativum Pam., King & Bakke), and seed-rot of flax (miscellaneous soil fungi). The seed was treated and packaged at Winnipeg, then sent to nine stations in the United States and seventeen stations in Canada for sowing in experimental plots. The data obtained were compiled and analysed at Winnipeg.

In addition to the information given in Table I, the following notes concerning the 11 new treatments may be of interest.

Actidione -- This is the first antibiotic to appear in these trials. Both formulations were supplied by Dr. A. W. Henry, University of Alberta. Not particularly effective against any of the plant diseases considered.

Orthocide 75 -- A dust, containing 75% captan, supplied by the California Spray-Chemical Corporation. It did not seem to be sufficiently effective against any of the cereal smuts, but was effective against seedling blight and seed rot.

Ortho Seed Guard -- A dust, containing 50% captan and 16.5% benzene hexachloride derived from lindane, supplied by the California Spray-Chemical Corporation. It proved to be somewhat low in effectiveness against smut, but very effective against seedling blight and seed rot. Slightly phytotoxic to wheat.

Puratized C4-10 -- A dust mercurial containing phenyl mercury-2-mercaptobenzothiazole (4.75% Hg) supplied by the Gallowhur Chemical Corporation. Quite effective against smut and fairly good against seedling blight and seed rot. Slightly phytotoxic to wheat.

Puratized C13-1212 -- A dust, containing phenyl mercury formamide (7.8% Hg). Effective against smut and moderately good against seedling blight and seed rot. Slightly phytotoxic to wheat.

San -- Two dusts under this name were received for testing from Green Cross Insecticides (The Sherwin-Williams Co. of Canada). The earlier of the products contained 5% Hg as mixed phenyl mercury acetate and ethyl mercury chloride. The later one contained 6% Hg as phenyl mercury acetate only. Both products were effective against smut and moderately so against seedling blight and seed rot. Both proved to be slightly phytotoxic to wheat.

Liqui-San -- A fluid, containing 3% Hg as phenyl mercury acetate, supplied by Green Cross Insecticides. Slightly less effective than either type of "San" in controlling smut of wheat and oats, seedling blight of wheat, and flax seed rot. Slightly phytotoxic to wheat.

Merculine -- A fluid, containing 4.2% Hg as phenyl mercury salicylate, supplied by H. L. Woudhuysen and Associates. Effective against smut and seedling blight of wheat, smut of barley, and to a lesser degree against smut of oats. The poor control of seed rot in flax may be due to under-dosage, as a subsequent test in the greenhouse indicated. Slightly phytotoxic to wheat.

Mercusol -- A fluid, containing 0.84% as phenyl mercury salicylate and 1.9% copper as copper resinate, supplied by H. L. Woudhuysen and Associates. At the dosage used it did not give satisfactory control of smut or seed rot, but gave fairly good control of wheat seedling blight. Slightly phytotoxic to wheat.

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[1] Contribution No. 1360 from the Botany and Plant Pathology Division, Science Service, Department of Agriculture, Canada.

[2] Senior Plant Pathologist, Plant Pathology Laboratory, Winnipeg, Manitoba.

Table 1. Summary of results obtained with two re-tested and eleven new products developed for seed treatment[a].

Treatment[b]	Dose (oz./bu.)		Percentage smut[c]			Germination[d]	
	Cereals	Flax	Wheat	Oats	Barley	Wheat	Flax
Control (dry seed)	0.0	0.0	25.7	9.5	3.2	65.3	19.8
Ceresan M (dust)	0.5	1.5	0.3	0.1	0.8	76.1	33.2
Spergon (dust)	2.0	2.0	0.7	1.6	0.7	72.5	21.9
Vancide 51 (fluid)	4.0	8.0	2.9	4.6	1.6	72.1	27.2
Actidione (0.5% dust)	0.5	0.5	4.5	5.6	2.7	65.9	16.5
Actidione (1.0% dust)	0.5	0.5	3.4	4.6	3.0	68.7	14.6
Orthocide 75 (dust)	0.75	2.0	5.7	2.5	1.3	73.6	36.6
Ortho Seed Guard (dust)	1.5	3.0	4.8	2.5	1.0	77.1	36.0
Puratized C4-10 (dust)	1.0	1.0	0.3	0.3	0.9	72.6	27.1
Puratized C13-1212 (dust)	0.5	0.5	0.3	0.2	0.9	71.6	26.3
San (dust without EMC)	0.5	1.5	0.2	0.5	1.1	72.1	29.0
San (dust with EMC)	0.5	1.5	0.5	0.2	1.0	73.5	30.2
Liqui San (fluid)	0.75	2.25	1.0	1.7	0.9	71.5	27.6
Merculine (fluid)	0.5	0.5	0.3	1.2	0.7	75.1	21.9
Mercusol (fluid)	0.5	0.5	9.4	3.6	2.2	72.6	19.5
Least significant difference (5% point)			6.4	1.6	1.1	1.5	4.3

[a] Means of data from 11, 13, 13, 10, and 12 stations for wheat bunt, oat smut, barley smut, wheat seedling blight, and flax seed rot, respectively.
[b] Spergon and Vancide 51 are re-tested products.
[c] Percentage of smutty heads or panicles.
[d] Seedling-blight of wheat and seed-rot of flax.

The results obtained with the sixteen older products for sale in Canada prior to 1953 are summarized in Table 2. All of them, except perhaps Mercury-lindane, were effective against wheat bunt. Effective against oat smut were: Ceresan M, Half-ounce Leytosan, Leytosan G. 91, Mergamma C, Merlane, Panogen 14, PMAS (10% in water); effective against barley smut were: Ceresan M, Agrox C, Half-ounce Leytosan, Leytosan G. 91, Mercury-lindane, Mergamma C, Merlane, and PMAS (10% in alcohol); against seedling blight of wheat: Ceresan M, Agrox C, Half-ounce Leytosan, Leytosan G. 91, Mergamma C, and Leytosol C; and against seed rot of flax, Ceresan M, Agrox C, Mergamma C, Panogen 14, and PMAS (10% in alcohol).

GREENHOUSE TRIALS

It seems to be well known that the holding of treated seed in storage for a day or longer before sowing often improves the efficiency of seed treatment, this being particularly true for volatile seed dressings which do not mix easily with seed. In Canada, the recommended period of storage is one day for wheat and eight days for oats and barley. This recommendation applies however, to seed dressings most of which are no longer offered for sale in Canada, and therefore requires scrutiny and possible revision.

To obtain information on the storage requirements of wheat, oat, and barley seed treated with modern seed dressings, a part of the seed utilized for the 1953 cooperative seed treatment trials was sown in the greenhouse, after about an hour, and one, two, four, six, and eight days, of storage in closed glass jars kept at room temperature. The seed was sown at the rate of 25 seeds per 6-inch pot, in duplicate, 100-seed, parallel series. At heading, the plants were examined for smut, and the storage period at and after which no smut was found was taken to be the minimum storage period required by the treatment under consideration. It was realized that the data from a trial in the greenhouse might not truly represent the results obtainable under

Table 2. Summary of results obtained with 16 seed treatments for sale in Canada prior to 1953[a]

Treatment	Dose (oz./bu.)		Percentage smut[c]			Germination[d]	
	Cereals[b]	Flax	Wheat	Oats	Barley	Wheat	Flax
Control (dry seed)	0.0	0.0	23.6	9.4	3.7	66.9	21.3
Ceresan M (dust)	0.5	1.5	0.4	0.1	0.9	76.2	39.8
Agrox C (dust)	0.5	1.5	0.6	1.9	0.8	78.0	36.0
Anticarie SD (dust)	0.5	0.5	0.1	8.3	2.5	70.5	20.6
Bunt cure (dust)	0.5	0.5	0.1	7.5	2.6	69.9	24.1
Bunt-no-more (dust)	0.5	0.5	0.1	6.7	2.9	73.5	20.7
Half-ounce Leytosan (dust)	0.5	1.5	0.8	0.5	0.7	75.4	29.7
Leytosan G. 91 (dust)	2.0/1.4	5.0	0.4	0.6	0.7	75.1	31.3
Mercury-lindane (dust)	1.6/1.2	4.0	1.5	1.3	0.8	72.3	23.9
Mergamma C (dust)	2.0/1.4	5.0	0.3	0.3	0.8	76.7	33.9
Merlane (dust)	2.0/1.4	5.0	0.2	0.0	0.7	72.9	30.4
Tritisan C (dust)	0.5	0.5	0.4	3.3	1.7	68.3	22.3
Leytosol C (soluble powder)	0.5	1.5	0.5	1.8	1.3	76.2	27.9
Panogen 14 (fluid)	0.75	1.5	0.2	0.1	1.0	73.3	37.9
PMAS (10% in water)	0.5	1.5	0.1	0.0	1.1	73.3	30.5
PMAS (10% in alcohol)	0.5	1.5	0.5	2.0	0.9	70.7	34.0
PMAS (5% in alcohol)	0.75	2.25	0.6	1.9	1.0	73.8	32.4
Least significant difference (5%)			5.9	1.1	1.4	4.0	6.3

[a] Means of data from 9, 11, 10, 8, and 7 stations for wheat bunt, oat smut, barley smut, wheat seedling blight, and flax seed rot, respectively.

[b] Where two doses for cereals are shown, e.g. 2.0/1.4, 2.0 is the dose for wheat and 1.4 is the dose for oats and barley.

[c] Percentage of smutty heads or panicles.

[d] Seedling blight of wheat and seed rot of flax.

field conditions, but since soil temperature, and soil moisture, was more easily controllable in the greenhouse than in the field, it was thought that a trial in the greenhouse was well worth while.

The results (Table 3) obtained in the greenhouse indicate that wheat seed contaminated by bunt and treated with dressings containing 40% hexachlorobenzene (Anticarie, Bunt cure, Bunt-no-more) or 60% pentachlornitrobenzene (Tritisan C) need not be stored before sowing. In oats and barley, the amount of smut was unaffected, even after the treated seed was stored for eight days. The results for organic mercury dusts (Agrox C, Ceresan M, Half-ounce Leytosan), organic mercury fluids (Leytosol C, Panogen 14, 10% PMAS, 5% PMAS), and dusts containing organic mercurials mixed with benzene hexachloride (Leytosan G. 91, Mercury-lindane, Mergamma C, Merlane) were variable but show that the storage period for wheat treated with organic mercury ought to be at least four days, instead of one day as hitherto recommended. For oats and barley, there seems to be no pressing need of increasing the storage period now recommended, although more information is desirable.

The following workers, to whom the writer is grateful for their help, assisted with the project in 1953: Dr. C. S. Reddy (Ames, Iowa), Mr. A. A. Guitard (Beaverlodge, Alberta), Dr. E. R. Hehn (Bozeman, Montana), Mr. W. H. Johnston (Brandon, Manitoba), Dr. C. M. Nagel (Brookings, South Dakota), Mr. J. E. Campbell (Charlottetown, Prince Edward Island), Drs. A. W. Henry and L. E. Tyner (Edmonton, Alberta), Dr. W. E. Brentzel (Fargo, North Dakota), Dr. R. H. Porter (Ft. Collins, Colorado), Mr. P. N. Grainger (Fredericton, New Brunswick), Dr. W. Crosier (Geneva, New York), Dr. D. N. Huntley and Prof. B. H. McNeil (Guelph, Ontario), Mr. A. L. Martin (Indian Head, Saskatchewan), Mr. E. C. Lowe (Lacombe, Alberta), Dr. M. W. Cormack and Mr. J. S. Horricks (Lethbridge, Alberta), Dr. C. D. Arny (Madison, Wis-

Table 3. Period of storage before sowing required by cereal seed when treated to control surface-borne smut.

Name of seed dressing	Percentage and name of active ingredient[a]	Physical state of dressing[b]	Minimum storage period (days)		
			Wheat bunt	Oat smut	Barley smut
Agrox C	5% Hg	WP	6	8+	8+
Anticarie SD	40% HCB	WP	1	No control	No control
Bunt cure	40% HCB	DP	0	No control	No control
Bunt-no-more	40% HCB	DP	0	No control	No control
Ceresan M	3.2% Hg	WP	6	1	8+
Half-ounce Leytosan	4% Hg	DP	4	4	8+
Leytosan G. 91	1.5% Hg + 43%BHC	DP	4	8+	8+
Leytosol C	2.7% Hg	SP	6	8+	8+
Mercury-lindane	1.5% Hg + 50%BHC	WP	6	8+	8+
Mergamma C	2.0% Hg + 40%BHC	WP	8+	6	8+
Merlane	1.7% Hg + 40%BHC	DP	6	0	8+
Panogen 14	1.4% Hg	L	6	6	8+
PMAS (10%)	6.0% Hg	L	6	8+	6
PMAS (5%)	3.0% Hg	L	8	8+	8
Tritisan C	60% PCNB	DP	0	No control	No control

[a] Active ingredient: Hg = Mercury; PCNB = pentachlornitrobenzene; HCB = hexachlorobenzene; BHC = benzene hexachloride.
[b] Physical state: WP = wettable powder; DP = dry powder; SP = soluble powder; L = liquid.

consin), Mr. H. R. Ballantyne (Melfort, Saskatchewan), Mr. W. J. Breakey (Morden, Manitoba), Mr. V. R. Wallen and Mr. Wm. Bell (Ottawa, Ontario), Dr. C. S. Holton (Pullman, Washington), Dr. R. O. Lachance (Ste. Anne de la Pocatiere, Quebec), Mr. M. B. Moore (St. Paul, Minnesota), Dr. R. C. Russell (Saskatoon, Saskatchewan), Mr. A. G. Kusch (Scott, Saskatchewan), Mr. D. S. McBean (Swift Current, Saskatchewan), and Mr. H. A. H. Wallace (Winnipeg, Manitoba).

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RELATIVE EFFICIENCY OF VARIOUS METHODS OF INDUCING FIELD INFECTIONS WITH HELMINTHOSPORIUM TURCICUM AND PUCCINIA SORGHI[1]

A. L. Hooker

In inaugurating a breeding program in corn for resistance to leaf blight incited by Helminthosporium turcicum Pass. and rust incited by Puccinia sorghi Schw., it seemed desirable to obtain data on the relative efficiency of various methods of inducing field infections in central Iowa with these two pathogens. The fact that these methods may be of value for consideration by other investigators has prompted the publication of a brief description of them and a summary of the pertinent results.

Materials and Methods

Three inbred lines of corn (WF9, L317, and Os426) were selected for this study. One hundred and eighty-eight field plots, each consisting of three 13-plant rows, were planted in the field on May 6, 1953. Each plot contained one row of each inbred line in a random order and was bordered on two sides by a single hybrid and on each end by a 40-inch alley. The field was divided into two replications and treatments were assigned to plots in each replicate at random.

The methods of inoculation are listed in Tables 1, 2, and 3, along with the dates of application. In the hypodermic inoculations, 9 cc of inoculum was injected into each plant through the unrolled leaves using a Becton, Dickinson continuous flow syringe (No. 470S0) equipped with a Huber point needle (18 G, 2 in.). A B-D adaptor (No. 470C) was substituted for the needle and this unit was used to drop 9 cc of inoculum into the leaf whorl of each plant for the leaf whorl inoculations. In the spray applications, the inoculum was sprayed on the plants with a knapsack sprayer, operating at about 15 pounds pressure, at the rate of 25 cc for each plant. Dusts were applied with a hand duster, and the pulverized leaves were applied by dropping a small handful into the leaf whorl of each plant.

Inoculum of H. turcicum for hypodermic, leaf whorl, and spray applications was prepared as described by Elliott and Jenkins (1). Eleven isolates from Iowa and Wisconsin were blended in the preparation of the inoculum. The pulverized leaf inoculum was prepared by grinding dry infected leaves, which had been collected the previous autumn and hung in mesh bags in an unheated barn through the winter.

Urediospores of P. sorghi were increased in the greenhouse on susceptible corn seedlings throughout the spring of 1953 and stored at 10° C. These were composited and mixed for field use. Spore suspensions were prepared just prior to field use by adding .05 grams of spores to 250 cc of water and blending in a Waring blendor for 30 seconds. This was added to 750 cc of the suspending medium and used without further dilution in the field. In the dust treatments, the spores were diluted at the rate of 1 part spores to 1000 parts talc by weight. A casein product (CI 510, Western Condensing Company, Appleton, Wisconsin) was diluted 1 to 10 with talc for one of the treatments.

In those treatments in which both H. turcicum and P. sorghi were applied, spores of P. sorghi were added to the H. turcicum inoculum according to the same procedure employed in the preparation of the P. sorghi inoculum. Gelatin where indicated was a 2% solution.

Preliminary notes of disease development were taken on July 17 and August 7. Detailed notes were recorded on August 26. Ten plants in the interior of each row were individually scored for disease development. Leaf blight ratings ranged from 0 to 10 according to the ratings of Jenkins and Robert (2). Rust was recorded as percentage of leaf area covered, using the scale of Peterson et al (3). A second set of detailed observations, planned for mid- or late September, was not made because unusually dry weather dried the leaves prematurely and prevented spread of disease. As the lower leaves of Os426 died early in the season, leaf blight ratings were unreliable, and therefore Os426 was left out of the final analyses of the data.

The ten individual plant ratings were averaged to give a line rating for each plot. The data were analyzed as four factorial experiments: one for the leaf blight treatments, one for the rust treatments, and one each for leaf blight and rust in those treatments receiving H. turcicum and P. sorghi simultaneously. Correlation coefficients were calculated between paired treatments in which separate and simultaneous inoculations with H. turcicum and P. sorghi were conducted.

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Table 1. Average leaf blight ratings for two plots of inbreds WF9 and L317 for various methods and times of inoculation with H. turcicum and a summary of the statistical analysis.

Dates of application	Method of application					
	Hypodermic	Leaf whorl	Water spray	Water and gelatin spray	Pulverized leaves	Checks
June 29	4.34[a]	3.23[a]	3.52	2.75		
July 6	2.56[a]	2.00[a]	1.24[a]	1.25[a]		
July 13	1.54	1.13	1.31	0.38		
July 20			1.80	1.36		
June 22 and July 6	3.95	4.12				
June 22 and July 13	3.48	2.17	1.66	2.20		
June 29 and July 13	4.60	2.58	1.11	2.09		
June 29 and July 20			1.78	1.82		
June 22, July 6, and 20			2.07	2.80		
June 26, July 3, and 10					8.42	
June 22, 26, 29, July 3, 6, 10, 13, and 17	6.80	5.00	4.92[b]	4.62[b]		
						0.14[c]

Source of variation	df	MS	F
Treatments	45	13.49	15.16**
Lines	1	20.68	23.24**
Treatments x Lines	45	.55	.62
Replicates	1	.02	.02

** Significant at 1% level
L. S. D. at .05 level 1.33
[a] Average of 4 plots
[b] Additional spray application made July 20
[c] Average of 14 plots

Experimental Results

Highly significant differences were measured for leaf blight ratings among methods of inoculation as well as between inbred lines as shown in Table 1. Early dates of application generally resulted in heavier infections than later applications. Where liquid inoculum was used, only frequent and repeated inoculations resulted in high levels of infection. Hypodermic inoculations generally resulted in higher disease readings than leaf whorl applications but were less desirable because of mechanical injuries to the plant. This was especially so where repeated hypodermic inoculations were made. The addition of gelatin to the spray suspension did not measurably change the effectiveness of the inoculum. Leaf whorl applications were just as effective as spraying the entire plant. Pulverized leaves dropped into the leaf whorl resulted in the highest level of infection; exceeding the best infection obtained with liquid inoculum by a quantity greater than the L.S.D. at the 5% level. This method of inoculation also resulted in a high level of infection at silking time of the host. As the uninoculated check plots had an exceptionally low level of leaf blight, the infections obtained in the inoculated plots resulted largely from the inoculation and not from natural infection. Leaf blight ratings for WF9 and L317 in this study showed approximately the same differential as previously reported (1).

Significant differences among rust scores for the various inoculation treatments with P. sorghi were obtained (Table 2). Most inoculation treatments resulted in significantly more rust than occurred in the uninoculated check plots, although a rather high level of natural infection occurred, especially on the more susceptible inbred L317. Hypodermic inoculations were supe-

Table 2. Average percentage of rust for two plots of inbreds WF9 and L317 for various methods and times of inoculation with P. sorghi and a summary of the statistical analysis.

Dates of application	Method of application						
	Hypodermic	Leaf whorl	Water spray	Water and gelatin spray	Talc dust	Talc and casein dust	Checks
June 29	25.49[a]	18.80[a]					
July 6	19.26[a]	16.81[a]					
July 10			12.57	17.18			
July 13	20.90	18.68					
June 22 and July 6	28.75	19.02					
June 22 and July 13	24.70	15.44					
June 29 and July 13	33.25	19.58					
July 10 and 13					21.04[b]	19.92[b]	
							9.91[c]

Source of variation	df	MS	F
Treatments	24	155.76	7.94**
Lines	1	18,325.04	934.00**
Treatments x Lines	24	45.70	2.33**
Replicates	1	26.03	1.33

**Significant at 1% level
L. S. D. at .05 level 6.29
[a] Average of 4 plots
[b] Applied in late afternoon
[c] Average of 10 plots

rior to other treatments employing liquid spore suspensions. However, WF9 frequently exhibited a higher infection with hypodermic inoculations than the natural difference in resistance between it and L317 would indicate and this may account for the highly significant Treatments x Lines interaction (Table 2). Limited data indicated that inoculation with diluted spores dusted on the plants in the late afternoon was effective, but had a disadvantage in the relatively large quantity of urediospores needed. Notes taken early in the season showed that most of the rust infections had taken place early and that little secondary spread had occurred after pollination.

A limited number of treatments were conducted in which plants were inoculated simultaneously with H. turcicum and P. sorghi (Table 3). The same general relationships among methods and times of inoculation prevailed where simultaneous inoculations were conducted as where individual pathogens were inoculated. Approximately the same levels of infection occurred whether the pathogens were inoculated individually or together as indicated by the significant correlation coefficients (Table 4).

Discussion and Summary

A number of different methods result in field infections with Helminthosporium turcicum and Puccinia sorghi; however, some are superior to others in effectiveness, economy of application, and in other respects.

Pulverized leaves infected with H. turcicum applied to the leaf whorl two or three times resulted in the highest level of leaf blight in this study. This method was the most economical of those tested and has an additional advantage in that it can be used by investigators who do not have facilities for isolating and culturing the pathogen. Also, relatively unskilled labor may be employed in conducting most of the operations. Undoubtedly improvements and refinements can be made, but the superiority of this method over the others tried in this study would indicate

Table 3. Average leaf blight ratings and average percentage of rust for two plots of inbreds WF9 and L317 for various methods and times of simultaneous inoculations with both H. turcicum and P. sorghi and a summary of the statistical analysis.

Dates of application	Method of application							
	Hypodermic		Leaf whorl		Water and gelatin spray		Check	
	Leaf blight	Rust	Leaf blight	Rust	Leaf blight	Rust	Leaf blight	Rust
June 29	3.65	21.10	2.08	17.88	1.61	11.62		
July 6	2.20	19.72	1.10	14.15	2.60	18.92		
July 13	2.11	18.25	0.82	14.45	0.56	13.25		
June 22 and July 6	3.70	16.92	4.62	19.38	2.45	13.88		
June 22 and July 13	2.29	15.68	1.95	16.50				
June 29 and July 13	3.28	25.20	3.15	14.75	2.85	16.82		
							0.09	8.38

Source of variation	df	Leaf blight		Rust	
		MS	F	MS	F
Treatments	17	5.53	3.01**	58.20	4.08**
Lines	1	11.57	6.29*	15,919.23	1,114.79**
Treatments x Lines	17	.52	.28	55.15	3.86**
Replicates	1	4.09	2.22	66.90	4.68*

* Significant at 5% level
** Significant at 1% level
L. S. D. at .05 level for leaf blight 1.95; for rust 5.42

Table 4. Summary of correlation coefficients for data pertaining to separate and simultaneous inoculations with H. turcicum and P. sorghi.

Items correlated	n	r
H. turcicum alone and H. turcicum with P. sorghi.	16	.766**
P. sorghi alone and P. sorghi with H. turcicum.	12	.638*
Over both above.	28	.965**

* Significant at 5% level
** Significant at 1% level

that it warrants further consideration.

Hypodermic inoculations with H. turcicum were effective but their frequent use resulted in serious mechanical injury to the plants. If liquid suspensions of spores and mycelium are employed, leaf whorl applications would seem to be most desirable. Repeated applications appear to be necessary.

Hypodermic inoculations with urediospore suspensions in water resulted in the best infections with P. sorghi. However, this method may not be effective in measuring natural differential resistance. Dusting with spores seemed to be an effective method of establishing infection but would not be economical on a large scale owing to the expense of increasing a sufficient quantity of urediospores.

At low levels of infection, the data indicate that resistance to both H. turcicum and P. sorghi can be evaluated in the same nursery. Simultaneous inoculations with these two pathogens can be made with no apparent antagonistic effects.

The low level of leaf blight in the uninoculated check plots indicated little natural infection with or spread of H. turcicum. This was probably due to the extremely dry conditions prevailing during the course of the experiment. During the period from June 22 to August 31 precipitation totaling 6.4 inches occurred on 19 days, but with more than 0.5 inch on only four days. Average minimum and maximum temperatures for this period were 61.5° and 85.3° F., respectively. This dry weather was favorable for a study of this type because as most of the disease in the inoculated plots was a direct result of the inoculation good comparisons could be made among the various treatments. Higher atmospheric humidity would presumably have been more favorable for disease spread and under these conditions many of the treatments might have been more effective. Efforts should be made to select an isolated area for a corn disease nursery and provide atmospheric moisture through overhead irrigation, or if this is not possible to select a site with natural high humidity.

Largely on the basis of this study, it is planned to install a permanent corn disease nursery for use in the general problem of breeding for disease resistance. A site isolated from other corn research plots and from farmer's fields has been selected. Overhead irrigation will be provided so that atmospheric humidity can be supplemented as needed by a fine water spray.

Leaf blight inoculations will be conducted with pulverized leaves supplemented by leaf whorl applications of a spore and mycelium suspension early in the season. New cultures or isolates of the pathogen will be added to the nursery at this time. Infected leaves will be collected each fall from the nursery for use the following year. Under this system the most virulent strains of the pathogen should tend to be propagated and maintained from year to year.

For rust in the field it is planned to inoculate susceptible spreader rows hypodermically and depend upon natural spread for most of the disease. Urediospores may be added to the H. turcicum inoculum applied to the leaf whorl early in the season.

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IOWA AGRICULTURAL EXPERIMENT STATION

EFFECT OF CROP ROTATION ON THE POPULATIONS OF MEADOW NEMATODE, PRATYLENCHUS LEIOCEPHALUS, IN NORFOLK LOAMY FINE SAND

J. M. Good, Jr., W. K. Robertson, and L. G. Thompson, Jr.

The use of crop rotations is a practical method of preventing parasitic nematode populations from building up in soils; however, according to Garriss (4), crop rotations have little effect on reducing the population once a high infestation has developed. Selecting a crop rotation that will curtail the build-up of meadow nematodes is difficult because of the large host range of Pratylenchus spp. The susceptibility of plants in the greenhouse is not necessarily a criterion of how the plant will respond in the field because of variations in root development, planting rates, moisture, aeration, tilth, and other factors. The relative increase of plant parasitic nematode populations under field rotation practices is probably the most effective means of obtaining a practicable answer to the selection of either a general rotation or one suited to the profitable production of a specific crop in the rotation. In the past few years the known number of plants susceptible to ectoparasitic and endoparasitic nematodes has increased to the extent that the damage to many field and truck crops has been evaluated. Steiner (6) and Christie (1) have reported the nematode damage on many plants in the southeast, particularly in Florida. In a survey of plants susceptible to the sting nematode, Holderman and Graham (5) reported that all grasses tested increased the population of Belonolaimus gracilis Steiner while Crotalaria and Spanish peanuts seemed to suppress the population of this nematode. Field crop rotation studies for control of root-knot nematodes conducted in Georgia by Gaines (3) showed that less root-knot infection was present in the three- and four-year rotations than in two-year rotations and continuous cropping. It was found that less root knot developed in susceptible crops following Spanish peanuts than after cotton, velvet beans, and weeds, which were less susceptible to root-knot infection than cowpeas, sweetpotatoes, and corn. In addition, root-knot infection was less when different cash crops were grown each year in rotations. Recent studies in North Carolina, as reported by Garriss (4), showed that meadow nematode damage is lower in the three- and four-year rotations than in the two-year rotation plots. Corn, oats, and grasses were found to be the most susceptible plants. Tobacco following either peanuts or oats and weeds was damaged less than when it followed either corn or cotton.

Methods

The rotation experiment from which data are reported here was set up at the North Florida Experiment Station, Quincy, in the Spring of 1947. Field plots of 1/15-acre size were laid out on virgin Norfolk loamy fine sand with a native vegetation which was predominantly wire grass (7). The rotation sequences are shown in detail in Table 1. Florida W-1 hybrid corn was grown the first two years and Dixie 18 hybrid corn the remaining years. Dixie Runner peanut was grown throughout the experiment. Red Rustproof No. 14 oat was planted the first three years and the Southland oat the last years. Bitter Blue lupine was grown the first five years and Alta Blue lupine the last years. The design of the experiment was a randomized block with each rotation replicated four times.

Approximately one quart of soil was taken from each plot on October 30, 1953 to a depth of six inches with a one-inch soil sampling tube. The sample was thoroughly mixed and 150 cc of soil were taken for the nematode counts. The nematodes were extracted by the Christie and Perry method (2) using the Baermann funnel, except that during the washing process the nematodes were retained on nylon parachute fabric. Nematodes were drawn from the funnel after 24 hours and counted under a stereoscopic microscope (magnification 85X). Species were identified periodically under a compound microscope.

Results and Discussion

Population counts were made of Pratylenchus leiocephalus Steiner, smooth-headed meadow nematode. Differences of large magnitude appeared to be present between the treatments and the samples, with the large population counts tending to be more variable than the samples with the smaller counts. To correct for this heterogeneity of errors and to scale the data to an additive form, the square root of sample counts was taken and analyzed statistically. The square root values are referred to as an "index". The analyses of the population counts and the "index" values are given in Table 1. The L.S.D.'s of the "index" values are considered a better means

Table 1. Numbers of Pratylenchus leiocephalus Steiner in soil samples from crop rotation experiment[a].

Rotation	Averages	
	Counts	Index[b]
Continuous:		
Peanuts (native)	4	1.99
Peanuts (lupine)	15	3.74
Corn (lupine)	324	17.69
Corn (native)	123	11.00
Two-year		
Peanuts (lupine)	14	3.62
Corn (native)	76	8.69
Three-year:		
Peanuts (lupine)	8	2.76
Corn (lupine)	269	16.26
Corn (oats)	158	12.22
L.S.D. .05	84	2.9
L.S.D. .01	112	4.1

[a] Samples taken at end of the cash crop growing season.
[b] Indexes are the square root of the sample counts.

of interpreting the data than the L.S.D.'s of the actual values[1].

P. leiocephalus was found in all samples. The population of meadow nematodes was increased by Dixie 18 corn and decreased by Dixie Runner peanuts. The smallest nematode count on corn was from the two-year rotation. The occurrence of the peanut crop in the three-year rotation reduced the population counts so that they were not significantly different from the counts obtained following peanuts in the two-year rotation or where peanuts were grown continuously. Peanuts and corn yields, however, were highest in the three-year rotations (7). These rotations were maintained at a relatively high state of fertility; this and other factors may counteract the damage caused by large numbers of meadow nematodes in the three-year rotations. There are other areas at the North Florida Experiment Station where corn appears to show moderate meadow nematode damage.

The data show that the meadow nematode population builds up to a greater extent under lupine than under native cover or oats. Lupine yields have been decreasing in these rotations. The poor stands and low vigor of lupines may be associated with the susceptibility of this plant to meadow nematodes and secondarily to invasion of the plants by pathogenic microorganisms.

The occurrence of Xiphinema sp., Hopolaimus sp., and mononchoid nematodes was studied. Hoplolaimus and Xiphinema were generally associated with corn. No apparent relationship was noticed between mononchoid type nematodes and rotation practices or numbers of plant parasitic nematodes.

Summary

A soil study was made to determine the effect of continuous cropping versus two- and three-year rotations on Pratylenchus leiocephalus populations. Soil samples were taken during the fall of the seventh year after the initiation of the experiment. Significantly greater numbers of nematodes were present in the soil following Dixie 18 corn than after Dixie Runner peanuts. The largest populations occurred when corn was grown continuously, but when grown in rotation with peanuts the numbers decreased. The lowest infestation following corn occurred in the two-year

[1] Dr. W. D. Hanson, Agronomy Department statistician, was consulted in regard to statistical interpretations of these data.

rotation, with intermediate numbers occurring where corn, the most susceptible plant, was grown two years and peanuts one.

Significantly more nematodes were found in the soil following lupine than after oats or native cover.

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MAIN FLORIDA AGRICULTURAL EXPERIMENT STATION, GAINESVILLE, AND NORTH FLORIDA AGRICULTURAL EXPERIMENT STATION, QUINCY, FLORIDA

HOT WATER AND SYSTOX FOR CONTROL OF FOLIAR NEMATODES IN BELLINGHAM HYBRID LILIES[1]

Harold J. Jensen and Fields E. Caveness[2]

Clones and seedlings of Dr. David Griffith's West Coast lily hybrids, generally known as "Bellingham Hybrids"[3], were brought from the U. S. Department of Agriculture Bellingham Bulb Station to Corvallis in 1936. Most of the hybrids survived and grew well during the following years except for occasional frost damage from which they usually recovered by mid-season. The planting was severely injured by frost during the spring of 1952. That year, the plants did not recover normally, but remained stunted, many plants having distorted discolored leaves (Fig. 1). The general appearance of the planting became worse as the season progressed, and plants with an earlier history of distorted, discolored foliage, turned brown and died prematurely. Flowerage was erratic, and many plants produced few or no blooms. Frost damage was eliminated as the sole cause of the abnormality when similar conditions appeared in plants being forced outdoors in a screen house at Beltsville, Maryland, grown from a 1951 sample of Corvallis clones sent to Beltsville for florist evaluation. At Beltsville a nematode was suspected by Dr. S. L. Emsweller, and Dr. G. Steiner confirmed a foliar infection by a nematode in the genus Aphelenchoides.

FIGURE 1. A Bellingham Hybrid lily infected with Aphelenchoides fragariae showing symptoms of distorted, discolored foliage. Approximate magnification x 3/8. (Photograph by H. H. Millsap)

FIGURE 2. A Bellingham Hybrid lily leaf section showing several Aphelenchoides fragariae in the tissue. Approximate magnification x 67. (Photograph by H. K. Phinney)

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[1] Published with the approval of the Director of the Oregon Agricultural Experiment Station as Technical Paper No. 827, Department of Botany and Plant Pathology.

[2] Assistant Nematologist, and Graduate Research Assistant, respectively, Oregon Agricultural Experiment Station.

[3] Name assigned to the group of lilies by Woodcock & Coutts in their book "Lilies," Charles Scribner's & Sons. 1935.

Table 1. Bellingham Hybrid lily selections found infected with foliar nematodes in the Corvallis planting.

USDA lot number	Common name	USDA lot number	Common name
1369 A	Mercer Girl	4153	Et-da-how
1369 K	Frances Larrabee	4175	Shuksan
1370	Star of Oregon	4520	
1370 O	Kulshan	4523	
1370 R	Douglas Ingram	4526	
1370 S	Cyrus Gates	4529	Terracotta
1836		4531	
3127		5071	
3244		5306	
3257		5312	
4152	Nisqually	5330	

Table 2. Effects of variations of hot water-formaldehyde bulb treatments on the incidence of Aphelenchoides fragariae.

Temperature of bath °C.	Number bulbs treated	Number plants sampled *	Average height (inches)	Number plants infected	Percent infected
40	50	46	34.36	20	43.48
44	50	50	32.87	1	2.00
48	50	40	24.63	0	0.00
Untreated control	51	51	27.06	27	52.94

* Several plants were accidentally damaged in cultivation.

Lilies in the Corvallis planting were found to be infected with a nematode identified as Aphelenchoides fragariae (Fig. 2). The distribution of the nematode in the Corvallis planting was confined to the Bellingham Hybrids and their common components Lilium humboldti and L. pardalinum, and the Sunset variety of L. pardalinum. No infection was found in the many selections of L. speciosum and L. tigrinum in the same Corvallis planting. The U. S. Department of Agriculture lot numbers of the infected hybrid lines, and common names where names have been assigned, are recorded in Table 1.

Two separate experiments were conducted to determine a satisfactory method of freeing these valuable lilies from their nematode parasites. The hybrid 4520 was used because this clone contained a large number of bulbs and appeared to be the most severely damaged. Variations of the standard hot-water treatment that McWhorter and Millsap (1), Courtney (2), and others have shown to be an efficient control of nematodes in lilies, and foliar sprays with Systox, shown by Feder (3) to be of nematodicidal value in ornamental bulb culture, were tested.

Hot Water-Formaldeyhde Treatment: Lots of 50 bulbs of uniform size were soaked for one hour in hot water-formaldehyde (1 pint of 38% formaldehyde to 25 gallons of water) baths maintained at 40°, 44°, and 48° C, respectively. All bulbs, including an untreated control of 52 bulbs, were dipped for three minutes in Spergon (5 ounces of 25% wettable Spergon in 3 gallons of water) immediately following heat treatment to prevent secondary rots.

Table 3. Effects of Systox foliar sprays on the incidence of Aphelenchoides fragariae in Bellingham Hybrid lilies.

Dilution of 42% Systox per 100 gal. of water	Number of applications	Number plants treated	Number plants sampled*	Average height (inches)	Number plants infected	Percent infected
1 pint	1	20	19	31.73	9	47.37
	2	25	24	31.13	8	33.33
	3	30	29	30.79	5	17.24
1 quart	1	25	25	32.72	4	16.00
	2	25	24	30.46	1	4.17
	3	25	22	31.41	1	4.55
1 gallon	1	25	23	31.74	0	0.00
	2	25	24	28.92	0	0.00
	3	25	24	24.17	0	0.00
Control	-	27	26	31.73	14	53.85

*Several plants were accidentally damaged in cultivation.

Systox Foliar Spray Treatment: Three dilutions of 42% Systox (1 pint, 1 quart, and 1 gallon, per 100 gallons of water) were applied respectively to three lots of 75 plants. All plants, including an untreated control of 26 plants, were grown from bulbs subjected to a Spergon dip similar to that used with the hot-water treatment. Each lot of 75 plants was subdivided into three portions, which received single, double, or triple applications of spray. Each portion consisted of 5 randomized replications of 5 plants, except that for the lot receiving the 1 pint dilution the single application was replicated 4 times and the triple application 6 times. The first spray was applied in early March when the plants had attained an approximate height of 3 inches. A three-week interval elapsed between each succeeding spray.

Results: Repeated sampling of leaves failed to reveal any nematodes until late August. Data appearing in Tables 2 and 3 were obtained by making 439 separate plant examinations. Each sample contained one or more leaves from every leaf-whorl of each plant. The leaves were macerated in water in a Waring Blendor to facilitate microscopic examination.

The hot water-formaldehyde bath of 48° C completely eliminated the nematodes (Table 2). However, bulbs treated in this manner sustained considerable injury, since the average height of the plants grown from the treated bulbs was much less than that of the control plants. The most vigorous plants were produced by bulbs receiving the 44° treatment although they were slightly shorter than plants from bulbs treated at 40°. The control plants made the best growth during the earlier part of the season, but their rate of growth slowed considerably in August owing to nematode injury. Later, 52 percent of the control plants were found to be infected.

A single foliage spray of Systox at the rate of 1 pint per 100 gallons of water did not control the nematodes (Table 3), but the amount of infection was reduced with each additional spray. The nematode infections were effectively reduced when two applications of the 1 quart rate were used. Complete control was achieved when sprays of the 1 gallon rate were applied. Unfortunately, the 1 gallon spray rate was accompanied by severe burning of the tips of the leaves and reduction of the average height of the plants. The Systox sprays had no noticeable effect on the flowers.

Summary: Practical control of the foliar nematode disease of Bellingham Hybrids caused by Apehlenchoides fragariae can be accomplished by: 1) a one-hour hot water-formaldehyde bath at 44° C, or 2) two or three applications of Systox foliar sprays at the dilution of 1 quart of Systox per 100 gallons of water. Control by these methods was achieved with no apparent injury to the lilies. Nematode infection was apparently eliminated by a hot water-formaldehyde bath at

48° or a Systox foliar spray at the rate of 1 gallon per 100 gallons of water. However, plant injury was observed when these severe treatments were used.

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, OREGON AGRICULTURAL EXPERIMENT STATION, CORVALLIS

A STUDY OF THE EFFICIENCY OF THE CATCHING ORGANS OF DACTYLARIA EUDERMATA (DRECHS.) IN RELATION TO HETERODERA ROSTOCHIENSIS (WR.) IN SOIL

S. A. Hutchinson[1] amd W. F. Mai

INTRODUCTION

There have been many accounts of the action of the catching organs of predaceous fungi, and attempts have been made to use such fungi in the control of diseases caused by soil-borne nematodes. Linford and Yap (1) have stated that the loss of top growth of pineapple due to nematode injury of roots was slightly reduced by the presence of Dactylella ellipsospora Grove in the soil. It has, however, been difficult to obtain precise information on the effect of the presence of such fungi in controlling a population of nematodes in the soil. The difficulties have been due mainly to the well-known problems of establishing or increasing the density of a suitable predaceous species in a mixed soil flora, and of analysing the results from experiments in the complex conditions found in the field.

It was thought, therefore, that useful information might be obtained by examining the action of one of these species of fungus in soil, in petri dishes, with a density of fungus higher than that likely to be obtained in the presence of a normal complex soil flora. In such a condition the effect of the fungus on the numbers of nematodes present would probably be greater than in field conditions, and it could be measured conveniently in the laboratory by comparison with control cultures. This report details the results of such an investigation.

EXPERIMENTAL

A strain of Dactylaria eudermata Drechs. was used for all experiments. This fungus was isolated from soil sent to the Department of Plant Pathology, New York State College of Agriculture, Cornell University, by Dr. W. E. Paddock of the Pennsylvania State College, in October 1950. On 2% malt agar, it grew prolifically, forming abundant conidia and typical adhesive network type catching organs within six to eight days growth at 24° C. Its efficiency in nematode catching was tested on agar and in soil in petri dishes.

Experiment 1 -- Observation of the Action of the Fungus in Agar Culture. The fungus was grown on 2% malt agar in petri dishes at 24° C until the whole agar surface was covered with mycelia and abundant catching organs had been formed. Drops of an aqueous suspension of a mixture of species of nematodes were then placed on the surface and the action of the fungus studied under the microscope. It was seen that both large and small nematodes frequently passed through the adhesive networks without being caught. In some cases, however, a nematode passing through or over a catching organ would suddenly have its motion arrested and despite vigorous squirming, only an occasional exceptionally large and active specimen would be able to tear itself free. The stimulus or condition which caused this sudden operation of the catching organ was not identified. It was not due to a simple or delayed thigmatropic response, as in some cases nematodes were caught on first contact with a previously untouched organ, while in others a nematode was seen to pass through an organ several times before it was caught. In old cultures, the networks were often enveloped in a mass of mucilage. Nematodes frequently came into contact with this mass, but did not stick firmly to it. It was noted that ten days after the introduction of the nematodes into the culture, the number caught by the fungus was very small in relation to the total number present. The experiment was repeated using Heterodera rostochiensis Wr. larvae with similar results.

Experiment 2 -- Examination of the Action of the Fungus in Soil Cultures in Petri Dishes. The fungus was grown in a thin layer of 2% malt agar in petri dishes as above. After six days growth at 24° C, sufficient steam-sterilized moist garden loam was added to each dish to form a layer approximately 1/4-inch deep above the agar. Three control plates, without the fungus, were set up under similar conditions, using agar and sterile soil from the same source. After a further incubation at 24° for ten days, mycelia of the fungus were formed abundantly over the surface of the soil of the planted plates, indicating that it had permeated the soil extensively. Approximately 5,000 larvae of Heterodera rostochiensis were then added to each plate.

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After a further eight weeks incubation, abundant living larvae were found in both planted and control plates. The total number of surviving larvae was not counted, as it was thought that the density of the fungus was so high that the survival of any substantial number of larvae in the planted soil was an adequate criterion of its inefficiency as a control agent in these conditions.

Experiment 3 -- Examination of the Effect of the Fungus on the Number of Immature Golden Nematode Females on Potato Roots. Six petri dish soil cultures of D. eudermata were set up as above and each was planted with approximately 5,000 larvae of H. rostochiensis after mycelium had appeared on the soil surface. After a further three weeks growth at 24° C the contents of each petri dish was thoroughly mixed with each of six 4-inch plant pots of sterile loam. Six similar control cultures were set up without the fungus, planted with 5,000 similar larvae, and subsequently mixed with the contents of each of six other 4-inch plant pots of sterilized loam. A potato seed piece was then planted in each pot and after six weeks growth, the number of new individuals of H. rostochiensis forming on the roots of each plant was estimated (2). An average of 24 immature females were observed on the roots of plants growing in soil to which larvae plus fungus were added, and 18 on those growing in soil to which larvae alone were added.

DISCUSSION

The inefficiency of adhesive networks of many species of predaceous fungi when grown in agar culture is well known, but it has not yet been found possible to examine the efficiency of the device visually in the soil. The presence of such organs must affect the nematode population to some extent. The purpose of this investigation was to determine whether this effect was likely to be significant in controlling nematode diseases of plants in the field. The density of the fungus in the soil in Experiment 2 was very much higher than that likely to be obtained in the most favorable conditions in the field, and larvae were distributed equally throughout the soil. In such conditions, it is thought that a fungus likely to be effective in controlling the population in the field must be shown to exert a high percentage kill of the nematode population. The results show that Dactylaria eudermata does not exert such a control. The results of Experiment 3 indicate that the presence of the fungus does not affect appreciably the number of immature females developing on potato roots. Relatively low numbers of immature females were observed on the roots of all potato plants. This unexplained high mortality of free larvae of the golden nematode in soil has been observed in other experiments. Other species of predaceous fungi, particularly those with constricting ring type catching organs, might be more effective. It is thought, however, that the results recorded here indicate that more extensive field trials with this species would be unprofitable.

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PENTACHLORONITROBENZENE SOIL TREATMENT FOR POTATO SCAB AND RHIZOCTONIA CONTROL[1]

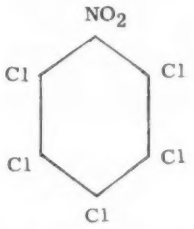
W. J. Hooker[2]

The use of fungicides applied to the soil for control of soil-borne diseases in potato fields is relatively unexplored in the United States. Pentachloronitrobenzene has been tested in Europe under the trade names Brassicol, and Folosan, and Bayer P for controlling a number of soil fungi.

Gram (2) reported that for reducing incidence of potato scab and sclerotia of Rhizoctonia solani, 100 percent pentachloronitrobenzene applied to the soil was the most effective compound in his trials. Brown (1) dusted pentachloronitrobenzene in potato clamps and thereby reduced the amount of sprouting and the severity of Rhizoctonia solani on the sprouts.

During the past two years, tests were made to determine the effectiveness of pentachloronitrobenzene in the peat soils of northern Iowa. The potato diseases, scab (Streptomyces scabies (Thaxt.) Waksman & Henrici) and scurf (Rhizoctonia solani Kuehn) were of greatest concern. Rather extensive trials had been made previously (Hooker and Kent, 3) in these peat soils using a wide range of materials. In these trials, sulfur was the most effective material tested for reducing scab.

The compounds of interest in the study reported herein were

pentachloronitrobenzene, 

, M275[3]

and two related chlorinated nitrobenzene compounds, M1197 and M273.

Limited tests were established in 1952 on a calcareous reed and sedge peat at Clear Lake, Iowa in which pentachloronitrobenzene, M275, was sprinkled into the open furrow, mixed into the soil, and the furrow closed. Rates of 100 and 200 lbs. per acre of 100% active material were relatively effective in reducing scab, and yields were not impaired. Because of the encouraging results in 1952 more extensive tests were prepared in 1953.

Broadcast trials were prepared by distributing chemicals by hand to plots, 35 x 50 feet, arranged in a Latin square design. The material was thoroughly disked into the soil and whole, B size Cobbler potato seed planted the following day, May 8, 1953. M275, 20% dust of pentachloronitrobenzene, was applied at rates calculated to be 500 and 1000 lbs. of 100% active material per acre. As a control, ground sulfur, 80 percent of which was 65 mesh or smaller, was used at 4000 lbs. per acre since this amount had been required for scab control in earlier trials on this field.

By the time the land could be fitted and the soil could be treated before planting, the period of low soil temperatures predisposing potato sprouts to early season Rhizoctonia solani infection was past. For this reason, subterranean stems were not examined until a month before normal maturity. At this time of the season, infection of stems by Rhizoctonia solani, Streptomyces scabies, and other soil fungi was advanced. Representative samples of stems were examined for infection by soil-borne fungi and the extent of damage evaluated by rating each stem as: healthy, no macroscopically visible necrosis; slight, only a few cortical lesions with the majority of the stem clean; moderate; and severe infection, in which the major portion of the cortical area of the stem was discolored or destroyed.

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[1]Journal Paper Number J-2465 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1104.

[2]Associate Professor, Botany and Plant Pathology Department, Iowa Agricultural Experiment Station.

[3]Pentachloronitrobenzene, 20% dust, will be referred to as M275. This and other chlorinated nitrobenzenes, M1197 and M273, were prepared by the Mathieson Chemical Corporation, Baltimore, Md.

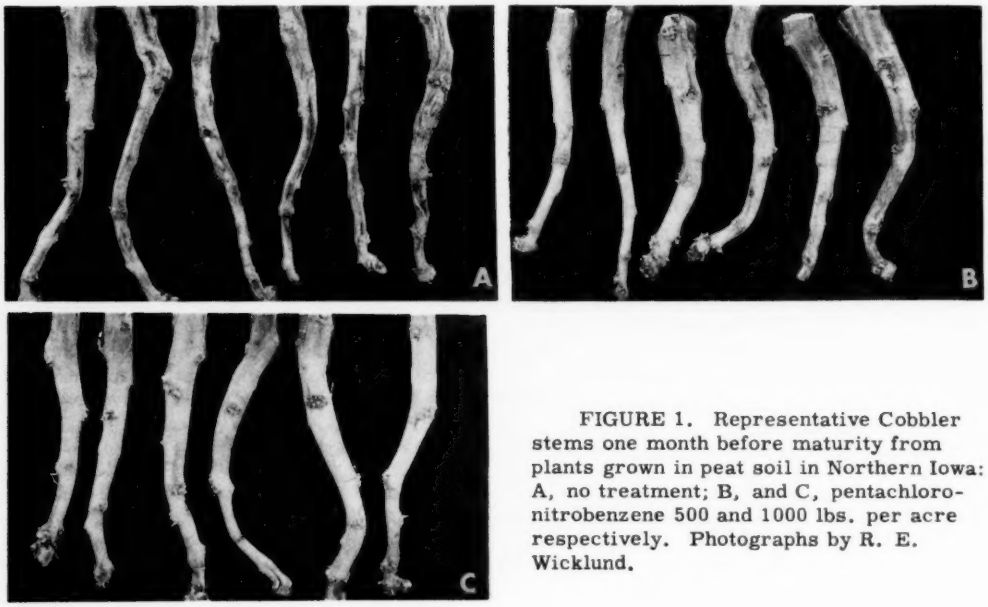

FIGURE 1. Representative Cobbler stems one month before maturity from plants grown in peat soil in Northern Iowa: A, no treatment; B, and C, pentachloronitrobenzene 500 and 1000 lbs. per acre respectively. Photographs by R. E. Wicklund.

Table 1. Subterranean stem necrosis, soil reaction, and yields of Cobbler potatoes grown in treated peat soil, broadcast application, at Clear Lake, Iowa, 1953.

Chemical and rate	Necrosis of stems 8/15/53					Soil reaction	Yield[a]
	None	Slight	Moderate	Severe	Disease index	Sept. 15	
lbs./A.	%	%	%	%		pH	bu./A
None	5	2	82	11	66	5.6	378
Sulfur, 4000	5	6	74	15	66	3.2	372
Pentachloronitrobenzene, 500[b]	20	3	73	4	53	5.5	415
Pentachloronitrobenzene, 1000[b]	27	11	61	1	46	5.4	405

[a]Total yield of tubers above 1 7/8 inch size harvested at maturity September 15. Yield differences are not significant.

[b]Pentachloronitrobenzene, 100% active.

The degree of control of cortical pathogens on potato stems (Table 1, Fig. 1) was marked in the 500- and 1000-lb. rates of M275. Stems in the sulfur plots were as severely diseased as those in the untreated control plots. In Iowa peat soils, it is very unusual to find stems as bright and free from necrosis as were obtained with broadcast pentachloronitrobenzene.

Potato yields were slightly but not significantly higher with pentachloronitrobenzene than in the untreated control. Yield increases following sulfur treatment were not obtained this season. This is in contrast to rather consistent yield increases obtained in this same field with sulfur in previous years.

It is interesting to note that at harvest there was no appreciable change in soil pH following treatment with pentachloronitrobenzene whereas sulfur induced a considerable reduction in soil pH levels.

Scab incidence was rated (Table 2) in a manner similar to that used earlier (3). For this, only deep 3 to 4 type scab was considered in the reading. Tubers with no scab lesions or with a trace of infection, only 1 or 2 lesions (Table 2), would have made satisfactory grade as far as scab was concerned. Tubers rated moderate, 6 to 15 percent of the tuber surface with deep scab, would probably have been considered out of grade.

At the early harvest scab incidence was approximately equal in the sulfur treatment and in the low rate of M275. At the normal harvest M275 500 lbs. per acre was somewhat superior to the sulfur, and at the delayed harvest differences were even greater. M275 at 1000 lbs. per acre was generally better than at the 500-lb. level.

The amount of russeting of the tuber surface (Fig. 2, Table 2) was considerably higher in the untreated control than in the plots receiving either M275 or sulfur. Reduction in russeting of Cobbler tubers (3) has previously been noted in these soils following sulfur treatment. Since a similar reduction in russeting was obtained with pentachloronitrobenzene, it is probable that the superficial, shallow russeting of Cobbler tubers commonly obtained in Iowa peats is a mild type of scab infection.

Table 2. Scab incidence, russeting, and Rhizoctonia sclerotia on Cobbler tubers grown in treated soil, broadcast application, at Clear Lake, Iowa, 1953.

Chemical and rate	Scab incidence: None	Scab incidence: None and trace	Scab incidence: None through moderate	Russeted tubers	Tubers with Rhizoctonia sclerotia
lbs./A.	%	%	%	%	%
Early harvest, Aug. 20					
None	3	26	72	--	--
Sulfur, 4000	27	70	94	--	--
Pentachloronitrobenzene, 500	28	67	96	--	--
Pentachloronitrobenzene, 1000	40	81	97	--	--
Normal harvest, Sept. 15					
None	16	68	92	80	--
Sulfur, 4000	48	87	99	37	--
Pentachloronitrobenzene, 500	60	87	100	18	--
Pentachloronitrobenzene, 1000	83	96	100	18	--
Delayed harvest, Oct. 10					
None	26	56	86	79	69
Sulfur, 4000	44	77	94	47	50
Pentachloronitrobenzene, 500	61	91	100	42	31
Pentachloronitrobenzene, 1000	56	80	96	30	21

FIGURE 2. Representative Cobbler tubers harvested 25 days after maturity from broadcast plots receiving: A, no treatment; B, sulfur 4000 lbs. per acre; C and D, pentachloronitrobenzene at 500 and 1000 lbs. per acre respectively.

Table 3. Yields and appearance of Cobbler tubers grown in treated peat soil, furrow application, at Clear Lake, Iowa, 1953.

Chemical and rate	Yield[a]	Scab incidence: None	Scab incidence: None and trace	Scab incidence: None through moderate	Russeted tubers	Tubers with Rhizoctonia sclerotia
lbs./A.	bu./A.	%	%	%	%	%
None	372	31	70	94	54	39
Sulfur, 500	446	49	81	97	30	16
Pentachloronitrobenzene, M275						
50	476	55	86	99	11	8
100	385	59	86	98	10	7
200	378	70	86	97	7	4
500	378	73	93	99	5	6
1000	366	80	94	99	2	5
2000	348	82	97	100	2	1
Chlorinated nitrobenzene, M1197						
20	409	33	73	95	35	23
50	354	39	65	92	31	24
100	324	46	74	99	20	17
200	269	39	72	97	25	11

[a]Total yield of tubers above 1 7/8 inch size harvested at maturity September 15. Least significant differences at 5 and 1 percent levels are 83 and 111 bu. per acre.

The amount of 3 type scab was not decidedly different when harvest was delayed one month past normal as compared to normal harvest, and the amount of russeting was approximately equal at those two harvest times. The greatest difference between normal and delayed harvest was in the incidence of Rhizoctonia sclerotia on tubers. At the early and normal harvests, sclerotia were absent and very few in number, respectively, whereas at the delayed harvest, sclerotia were abundant on tubers from the untreated plots and rather common on tubers from the sulfur-treated plots. A marked reduction in the number of sclerotia was obtained with M275 at both levels.

Exploratory trials were prepared in which chlorinated nitrobenzene was sprinkled into the open furrow and thoroughly mixed with the soil before planting whole, B size Cobbler seed pieces. Sulfur 500 lbs. per acre applied in a similar manner served as a control, since in previous seasons it had been very effective in reducing scab. Thus, in the immediate vicinity of the seed piece and in the soil where tubers developed, actual concentrations of chemicals were approximately three times greater than indicated.

Pentachloronitrobenzene, M275, was effective in reducing scab at all rates tested (Table 3), and control was outstanding at the 1000- and 2000-lb. rates. Russeting of tubers and Rhizoctonia sclerotia on tubers were reduced with all rates of M275 tested. Yields were significantly increased with 50 lbs. of pentachloronitrobenzene, M275, per acre and even at 2000 lbs. per acre yields were not impaired.

A related chlorinated nitrobenzene, M1197, was ineffective in reducing deep scab, russet of tuber surface, and number of Rhizoctonia sclerotia on the tuber surface. At the high rate, 200 lbs. per acre, there was evidence of yield reduction.

A third related compound, M273, was highly phytotoxic and at rates of 20 lbs. per acre growth and stands were very poor. At higher rates potatoes did not survive.

Discussion and Summary

Pentachloronitrobenzene, M275, was very effective in reducing scab and Rhizoctonia on Cobbler potatoes in the peat soils of northern Iowa. In soils of this type, scab is a serious problem, and high rates of sulfur are required to effect control. In broadcast applications, 500 lbs. of 100 percent active pentachloronitrobenzene per acre gave very satisfactory control.

Where the chemical was incorporated in the furrow, 200 lbs. per acre appeared to be effective for disease control.

Yields were significantly increased with 50 lbs. per acre in furrow application. The phytotoxic level of pentachloronitrobenzene was very low as yields were not impaired by furrow applications of 2000 lbs. per acre.

Two other related chlorinated nitrobenzenes were tested. M1197 was generally ineffective in furrow application for reducing scab and it appeared to be relatively more phytotoxic than M275. M273 was very phytotoxic and appeared to be of little potential value for potatoes.

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IOWA AGRICULTURAL EXPERIMENT STATION, AMES

LIMA BEAN SEED TREATMENT TRIALS IN CALIFORNIA, 1950-52[1]

L. D. Leach, W. H. Lange, F. J. Hills, and J. B. Kendrick, Jr.[2]

Seed treatment of lima beans for protection against seed decay caused by soil-borne fungi has been a common practice in California for many years (5). A more recent development has been the treatment of seed with insecticidal compounds for the control of wireworms (Limonius spp., Melanotus spp., and Aeolus spp.) and seed corn maggots (Hylemya cilicrura (Rond.)). Since 1947 there has been a rapid increase in the use of lindane (99.95% gamma isomer of benzene hexachloride) in California for this purpose (2, 3, 4).

Greenhouse trials in pasteurized soil showed that 75% lindane at the rate of 2/3 ounce per 100 pounds of seed caused no measurable injury to the emergence or growth of Ventura lima bean seedlings (2). The same dosage on seeds of the Fordhook variety, however, caused a reduction and delay in emergence and reduced seedling weight. In subsequent trials it appeared that a dosage of 1/3 ounce per 100 pounds of seed was non-injurious.

When these treatments were used in commercial plantings in 1949, several Farm Advisors reported reduced stands in certain cases attributed to lindane seed treatment. The apparent contradiction between greenhouse results and field observations prompted the series of field trials reported in this paper.

Methods and Procedure: Large lima beans of the varieties Ventura and Concentrated Fordhook were treated in the laboratory in special equipment designed for small lots of seed. Slurry treatments described in this paper were applied by adding the correct amount of suspensions to beans, rotating in a small treating drum, as liquid sprays or by pouring the material slowly over the beans and allowing the treater to continue rotation for a sufficient length of time to insure uniform coverage.

The treatments for each year were placed in identical field trials by Farm Advisor collaborators at several locations throughout the important large lima bean growing areas of the State. A randomized block design was used with five or six replications at each location. A single replicate of a treatment contained 100 seeds dropped in a row 30 to 50 feet long.

Seedling counts were made to determine total emergence and normal seedlings. Observations were made to determine seed corn maggot or wireworm damage. In most of the trials the total emergence of seedlings provided a satisfactory measure of protective effects but in two cases where soil insects attacked the seedlings after emergence, the best measure of insecticidal protection was afforded by a count of the normal seedlings.

In order to evaluate treatment effects more critically, data for each year from trials having homogeneous error mean squares have been pooled for statistical analysis according to the procedure of Roessler and Leach (6).

Trials in 1950: As a measure of beneficial or injurious effects the 1950 trials with the variety Ventura were designed to compare treatments in commercial use with other combination treatments that showed promise in preliminary trials.

The combined results of eight field trials are reported in Table 1. All of the treatments improved emergence over that from non-treated seed. There was no evidence of harmful effects due to lindane. Since fungicides and insecticides were tested in various combinations but not separately, it was impossible to assign observed effects to individual components of the combination treatments.

In commercial fields, however, evidence of reduced emergence was again observed. These injurious effects appeared chiefly where lindane was used alone or where application methods resulted in mechanical damage to seed.

Trials in 1951: Other tests by Lange in 1950 indicated that a dosage as low as 1/3 ounce of 75% lindane per 100 pounds of seed gave good control of wireworms and seed corn maggots under most conditions. The trials in 1951 therefore, were designed to test, on both Fordhook and Ventura lima beans, the effectiveness of the 1/3 ounce lindane rate, to find the most beneficial

[1] These trials were made possible by the collaboration of the following University of California Farm Advisors: D. E. Creighton, R. A. Brendler, B. J. Hall, Harwood L. Hall, A. H. Holland, H. W. Schwalm, W. S. Seyman, and E. E. Stevenson.

[2] Respectively: Plant Pathologist, Associate Entomologist, Extension Agronomist, University of California, Davis, and Assistant Plant Pathologist, U. C. Citrus Experiment Station, Riverside.

Table 1. The effect of seed treatments on the emergence of Ventura lima beans. Values given are treatment means of the combined results of eight field trials conducted in 1950.

Treatments (oz. per 100 lbs. of seed)							
None	Spergon, 2[a] Lindane, 2/3	Spergon, 4[a] Lindane, 2/3	Spergon SL, 2[b] Lindane, 2/3	Spergon SL, 2[b] Lindane, 1/3 Chlordane, 1	Arasan SF, 1-1/3[b] Lindane, 2/3	Arasan SF, 1-1/3[b] Lindane, 1/3 Chlordane, 1	Arasan, 4[c] Lindane, 2/3
50.4	65.5	64.4	61.7	63.6	67.4	63.6	71.4
Significant difference		(19:1) -- 4.2		(99:1) -- 5.5			

[a] Dust treatments.
[b] Slurry treatments, 8 oz. of slurry per 100 lbs. seed.
[c] Dust treatment plus liquid fixation -- 8 oz. of water per 100 lb. of seed sprayed on to fix the dust.

combination of materials for seed treatment, and to isolate the effects of individual components of the combination treatments.

The fungicides Spergon, Spergon SL, and Arasan SF were used as they were the materials in widest commercial use. Vancide 51 was included because greenhouse trials showed it too was a promising fungicide. The results of these trials are summarized in Table 2.

It was obvious from these results that treating seeds with lindane alone reduced stands below that obtained with non-treated seed. In most cases, except for the two trials combined under column C in Table 2, the addition of a fungicide to lindane-treated seed corrected this effect. Subsequently Howe, Schroeder and Swenson (1) reported similar results in tests conducted in New York.

Arasan SF and Vancide 51 appeared to be somewhat superior to Spergon SL in protecting against seed decay.

Effects of Other Insecticides: Table 3 shows results of field trials where aldrin and dieldrin, as well as lindane, were used as insecticides. It can be seen that each of these compounds when used without a fungicide also reduced stands below that obtained with non-treated seed. In other trials conducted by Lange, all insecticides that were effective against soil insects also caused a reduction in stand when used without an adequate fungicide.

Trials in 1952: Trials in 1952 were designed to measure the protective and injurious effects of two dosages of lindane when used alone or in combination with fungicides. Comparisons were also made between two dosages of Arasan SF and Spergon SL, the two fungicides in widest commercial use.

In Table 4 it can be seen that 1/6 ounce of 75% lindane per 100 pounds of seed had a less harmful effect on stands than the 1/3 ounce rate. Doubling the recommended rate of fungicide failed to improve stands in these trials. The addition of a fungicide produced a marked improvement in stand and eliminated or markedly reduced the adverse effect shown by the lindane when used alone.

Trials Involving Seed Corn Maggots and Wireworms: Among the 33 trials conducted during the three years, only one trial showed severe damage by seed corn maggots and one by wire-

Table 2. The effect of fungicides, with and without lindane, on the emergence of lima beans. Results of field trials conducted in 1951.

Treatment (Oz. per 100 lbs. of seed)[a]		Total emergence (seedlings per 100 seeds) Averages of combined field trials			
Fungicide	Insecticide	A[b] (4 trials)	B[b] (2 trials)	C[c] (2 trials)	D[c] (1 trial)
		Comparison of Individual Treatments			
None	None	50.3	55.8	51.6	38.8
None	Lindane, 1/3	40.1	42.3	22.5	34.3
Spergon, 3	None	57.9	73.3	---	---
Spergon, 3	Lindane, 1/3	59.1	70.6	---	---
Spergon SL, 2	None	55.7	72.8	67.5	67.5
Spergon SL, 2	Lindane, 1/3	55.1	65.5	50.5	63.7
Arasan SF, 1-1/3	None	66.7	76.4	83.2	77.7
Arasan SF, 1-1/3	Lindane, 1/3	67.1	73.3	50.6	78.8
Vancide 51, 4	None	63.3	75.0	80.9	73.8
Vancide 51, 4	Lindane, 1/3	62.5	73.0	67.8	75.5
Significant difference	(19:1)	4.8	4.6	6.7	12.9
	(99:1)	6.4	6.1	8.9	17.2
		Comparison of Fungicides[d]			
None		45.2	49.0	37.0	36.6
Spergon, 3		58.5	71.9	---	---
Spergon SL, 2		55.4	69.2	59.0	65.6
Arasan SF, 1-1/3		66.9	74.9	66.4	78.3
Vancide 51, 4		64.2	74.0	74.4	74.7
Significant difference	(19:1)	3.4	3.3	4.7	9.1
	(99:1)	4.5	4.3	6.3	12.2
		Comparison of Insecticide[d]			
None		59.3	70.7	70.6	64.5
Lindane, 1/3		56.8	64.9	47.9	63.1
Significant difference	(19:1)	2.1	2.1	3.3	n.s.
	(99:1)	n.s.[e]	2.7	4.4	n.s.
		Interactions			
Fungicides x Lindane		**[f]	**	**	n.s.

[a] All materials applied as slurries except "Spergon, 3" which was applied as a dust.
[b] Ventura limas
[c] Concentrated Fordhooks
[d] Averages of all plots receiving the fungicide or insecticide indicated.
[e] N. S. -- not significant
[f] ** F Value exceeds the 1% level of significance.

Table 3. The effect of certain insecticide seed treatments, with and without a fungicide, on the emergence of Concentrated Fordhook lima beans. Values given are seedlings per 100 seeds planted and are treatment averages of 3 field trials.

Fungicide (Oz. per 100 lbs.)	Insecticides (Oz. per 100 lbs.)			
	None	75% Lindane 1/3	50% Aldrin 1	50% Dieldrin 1/2
Comparison of Individual Treatments				
None	47.3	26.4	22.8	25.9
Arasan SF, 1-1/3	80.7	60.0	65.6	62.9
Significant difference (19:1) -- 5.4 (99:1) -- 7.1				
Comparison of Insecticides[a]				
	64.0	43.2	44.2	44.4
Significant difference (19:1) -- 38.0 (99:1) -- 5.0				
Comparison of Fungicides[a]		None	Arasan SF, 1/3	
		30.6	67.3	
Significant difference (19:1) -- 2.7 (99:1) -- 3.6				
Insecticides x Arasan SF		Interaction n.s.		

[a] Averages of all plots receiving the insecticide or fungicide treatment indicated.

worms. In these two instances, the striking value of a combination seed treatment is evident (Table 5).

Where seed-corn maggots damaged the seedlings and seed decay was present, the addition of lindane alone produced fewer normal plants than non-treated seed. While non-treated seed produced only a 40 percent stand, the seed treated with fungicide alone averaged a 56 percent stand and the combination treatments yielded an average of 76 percent.

In the trial where wireworms seriously damaged the seedlings, the non-treated seed produced a 62 percent stand of normal plants, the fungicides alone averaged 68 percent, the insecticides alone averaged 71 percent, and the combination treatments averaged 87 percent, of the seeds producing normal plants. In both cases, the increase from the combination treatments was considerably greater than the sum of the separate effects of the two components.

Discussion: Since soil insects were of minor importance in these trials, it will be noted that the principal advantage of seed treatment resulted from protection against seed decay by use of an adequate fungicide.

It is apparent that lindane when used alone can cause serious reductions in lima bean stands, particularly when seed decay organisms are present. The comparison of the lindane dosage levels afforded by the data from the field trials in 1952 indicated that there is a slight reduction in emergence with increasing amounts of lindane. It is evident, however, by comparing the individual treatments that this reduction is due primarily to the treatments where lindane is used alone and that when fungicide is added the adverse effect is either eliminated

Table 4. The effect of levels of fungicides and lindane on emergence of lima beans. Results of field trials conducted in 1952.

Treatments (oz. per 100 lbs. of seed)[a]		Total emergence (seedlings per 100 seeds) Averages of combined field trials[b]	
Fungicide	Insecticide	A (8 trials)	B (3 trials)
		Comparison of Individual Treatments	
None	None	69.1	48.4
None	Lindane, 1/6	64.4	45.8
None	Lindane, 1/3	60.5	41.6
Arasan SF, 1-1/3	None	89.0	68.1
Arasan SF, 1-1/3	Lindane, 1/6	87.3	64.6
Arasan SF, 1-1/3	Lindane, 1/3	87.5	62.2
Arasan SF, 2-2/3	None	87.4	66.9
Arasan SF, 2-2/3	Lindane, 1/6	88.9	69.2
Arasan SF, 2-2/3	Lindane, 1/3	87.6	65.6
Spergon SL, 2	None	88.8	68.6
Spergon SL, 2	Lindane, 1/6	89.6	64.6
Spergon SL, 2	Lindane, 1/3	86.6	57.7
Spergon SL, 4	None	88.9	69.3
Spergon SL, 4	Lindane, 1/6	85.3	67.5
Spergon SL, 4	Lindane, 1/3	82.9	58.9
Significant difference	(19:1)	2.6	6.5
	(99:1)	3.5	8.6
		Comparison of Fungicides[c]	
None		64.7	45.2
Arasan SF, 1-1/3		87.9	65.0
Arasan SF, 2-2/3		88.0	67.2
Spergon SL, 2		88.3	63.6
Spergon SL, 4		85.7	65.2
Significant difference	(19:1)	1.5	3.8
	(99:1)	2.0	5.0
		Comparison of Lindane Levels	
None		84.6	64.2
Lindane, 1/6		83.1	62.3
Lindane, 1/3		81.0	57.2
Significant difference	(19:1)	1.2	2.9
	(99:1)	1.5	3.9
		Interactions	
Fungicide x Lindane		**	n.s.

[a] All applied as slurries.
[b] Trials with varieties Ventura and Concentrated Fordhook combined according to homogeneity of error mean squares.
[c] Averages of all plots receiving the fungicides or insecticide treatment indicated.

Table 5. The effect of combination seed treatments and their components on normal surviving lima bean seedlings where soil insects damaged stands.

Treatment[a] (oz. per 100 lbs. seed)		Normal seedlings (per 100 seeds)	
Fungicide	Insecticide	Trial where seed-corn maggots damaged stand	Trials where wireworms damaged stand
Comparison of Individual Treatments			
None	None	40.3	61.6
None	Lindane, 1/6	-	74.0
None	Lindane, 1/3	33.3	68.6
Spergon, 3	None	51.8	-
Spergon, 3	Lindane, 1/3	68.5	-
Spergon SL, 2	None	51.2	72.0
Spergon SL, 2	Lindane, 1/6	-	88.6
Spergon SL, 2	Lindane, 1/3	56.5	90.6
Spergon SL, 4	None	-	73.8
Spergon SL, 4	Lindane, 1/6	-	85.2
Spergon SL, 4	Lindane, 1/3	-	86.8
Arasan SF, 1-1/3	None	59.0	70.4
Arasan SF, 1-1/3	Lindane, 1/6	-	83.0
Arasan SF, 1-1/3	Lindane, 1/3	83.7	88.8
Arasan SF, 2-2/3	None	-	55.0
Arasan SF, 2-2/3	Lindane, 1/6	-	90.0
Arasan SF, 2-2/3	Lindane, 1/3	-	88.0
Vancide 51, 4	None	62.5	-
Vancide 51, 4	Lindane, 1/3	81.2	-
Significant difference	(19:1)	12.0	9.1
	(99:1)	16.0	12.1
Comparison of Fungicides[b]			
None		31.6	68.1
Spergon, 3		60.2	-
Spergon SL, 2		53.8	83.7
Spergon SL, 4		-	81.9
Arasan SF, 1-1/3		71.3	80.7
Arasan SF, 2-2/3		-	77.7
Vancide 51, 4		71.8	-
Significant difference	(19:1)	8.5	5.4
	(99:1)	11.3	7.1
Comparison of Insecticide[b]			
	None	53.0	66.6
	Lindane, 1/6	-	84.2
	Lindane, 1/3	64.6	84.6
Significant difference	(19:1)	5.3	4.1
	(99:1)	7.1	5.4
Interactions			
Fungicides x Lindane		**[c]	**

[a] All applied as slurries except "Spergon, 3" which was applied as a dust.
[b] Averages of all plots receiving the fungicides or insecticide indicated.
[c] ** F value exceeds the 1% level of significance.

entirely or is of minor importance. It appears that the presence of seed decay organisms and the occurrence of conditions conducive to the development of infection seem to be essential to the expression of injurious insecticidal effects. Most of the damage caused by insecticide treatments at suggested dosages (4) seems to be associated with an increase of seed decay.

Wherever wireworms or seed corn maggots were a factor, lindane combined with a good fungicide greatly improved stands. The choice of the most favorable dosage of lindane is extremely difficult. Applications of 1/6 ounce of 75% lindane per 100 pounds of seed were less injurious than the 1/3 ounce rate, especially in the absence of a fungicide, and in one case (Table 5, last column) gave as good control of wireworms as did the 1/3 ounce rate. In supplementary trials with severe corn seed maggot infestations, however, the 1/6 ounce rate proved to be insufficient.

Summary: Thirty-three field trials were conducted in 1950, 1951, and 1952, to obtain information concerning the efficacy of certain combination fungicide-insecticide seed treatments of large lima beans. In most of these trials, the components of the combination treatments were tested individually. The treatments were assessed for these points: (a) Protection against seed decay organisms. (b) Effectiveness in protecting against damage caused by seed corn maggots and wireworms. (c) Possible adverse effects of seed treatment on emergence.

In these trials the greatest benefit of seed treatment was due to protection against seed decay caused by soil-borne fungi. In nearly all of the trials, stands were materially improved by the use of a good fungicide.

A significant feature of these trials was a reduction in emergence when Fordhook and Ventura lima bean seed was treated with an insecticide alone. When the insecticide was combined with a fungicide, however, this adverse effect was eliminated or greatly reduced. One-sixth of an ounce of 75% lindane per 100 pounds of seed caused less damage than the 1/3 ounce dosage.

Soil insects were of minor importance in all trials except two. In these trials, the beneficial effects of the combination treatments are reflected by increased numbers of normal seedlings.

There is some evidence that 1/6 of an ounce of 75% lindane may give protection against soil insects when infestations are light or moderate. With heavy infestations of soil insects, however, treatment of large lima bean seeds with 1/3 of an ounce of 75% lindane per 100 pounds of seed will provide more adequate protection and the addition of a good fungicide can be expected to eliminate most of the injurious effects of the lindane and provide satisfactory protection against seed decay.

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TRANSMISSION OF COLLETOTRICHUM LAGENARIUM BY THE SPOTTED CUCUMBER BEETLE

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In field observations in Henderson County, North Carolina during the summer of 1952, it was noted that lesions caused by the anthracnose fungus, Colletotrichum lagenarium (Pass.) Ell. & Halsted, often occurred on cucumber seedlings at or near the sites of feeding injuries characteristic of those caused by the spotted cucumber beetle (Diabrotica undecimpunctata howardi). This suggested that the beetles might be vectors of the fungus. In order to investigate this relationship, the following experiments were completed.

In the first experiment, initiated in September, 1952, 27 anthracnose-infected Marketer variety cucumber plants in the fifth leaf stage of growth were transplanted from the field into 6-inch pots and 9 plants placed in each of 3 insect-proof cages in the greenhouse. Sixty spotted cucumber beetles were collected and 20 of them were allowed to feed on the infected plants in each cage for 48 hours, after which they were transferred to adjacent cages containing pots of healthy cucumber seedlings in the second-leaf stage of growth. A fourth cage containing healthy plants but no beetles served as a control. All possible precautions were taken to guard against accidental transmission of the fungus. After two weeks, the young plants were examined for anthracnose lesions. In the first replicate cage, 25 of 48 plants, and in the second replicate 5 of 30 plants, showed typical anthracnose lesions. Both stem and leaf infections were noted. No infection occurred on any of the 22 plants in the third replicate cage nor on the 19 control plants.

A second test under similar circumstances was initiated October 8, 1952. One plant out of a total of 56, 2 of 52, and 2 of 60 plants were infected with anthracnose in the 3 replicate cages, respectively. No infections occurred on control plants.

In a third experiment made in November, 1952, artificially infected and healthy Marketer variety cucumber plants in the first-leaf stage of growth were placed in pots at opposite ends of 4 replicate cages. Twelve spotted cucumber beetles were released in each cage and allowed to feed for two weeks. Control cages containing (a) 30 non-infected plants, (b) 40 non-infected plants and 12 beetles, and (c) 30 infected and 27 non-infected plants but no beetles, were incorporated in the test. At the conclusion of the test, 3 of 23 and 1 of 27 plants in 2 of the replicate cages were infected with anthracnose. No infection occurred on any of the 59 plants in the other 2 replicate cages nor on any of the control plants.

Although the percentage of plants that became infected in these tests was usually quite low and infection failed to occur in some replicates, we believe the results indicate that C. lagenarium was transmitted by the spotted cucumber beetle. In most instances, the lack of or low number of infections could be correlated either with a lack of feeding by the beetles or, in the case of artificially infected plants, with the fact that the lesions occurred mainly at the base of the stems where the beetles for the most part failed to feed.

The role of cucumber beetles in transmitting the bacterial wilt pathogen, Erwinia tracheiphila (E. F. Sm.) Holland, is well known. More recently it has been found that Pseudoperonospora cubensis (Burk & Curt.) Rostow. and probably Pseudomonas lachrymans (E. F. Sm. & Bryan) Carsner are transmitted by the spotted cucumber beetle (2) (1). Although it was suggested by Gardner (3) that the anthracnose fungus might be carried by beetles, results of his limited tests were negative. We found in the literature no other reference to the transmission of C. lagenarium by cucumber beetles.

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ANGULAR LEAF SPOT OF SQUASH

Peter A. Ark[1]

Two distinct bacterial diseases of squash are mentioned in phytopathological literature. Bryan (2) described in 1930 a bacterial leaf spot of Hubbard squash caused by a yellow organism, Xanthomonas cucurbitae. Prasad (4), in India, reported X. cucurbitae on cucumbers (Cucumis sativus). The occurrence of X. cucurbitae on cucumbers was confirmed by Bryan (3) in 1933. A bacterium, Erwinia aroideae, was described causing soft-rot of squash, in the field, by Ark and Tompkins (1) in 1938.

In recent years, a bacterial leaf spot was observed regularly in plantings of Black Zucchini squash (Cucurbita pepo) in the Colma area, near San Francisco, California. The disease was especially noticeable in August and September, but it can be found in that area at any time since this crop is grown all the year round and overhead sprinkling is used during the dry months.

The disease is characterized by distinct small and large brown spots, each with a very well expressed yellow halo around the necrotic center. Watersoaking of the dorsal spongy mesophyll of affected leaves is quite pronounced, especially at the time of watering or after a rain. Microscopic examination of water mounts revealed masses of bacteria oozing out of the cut edges of the spots. On culturing the spots in potato-dextrose-peptone agar media and incubating at 28° C, small, white-gray colonies with entire margins and some markings on the surface appear after 48 hours. Several colonies were transferred and established on potato-dextrose-peptone agar slants. A water suspension of the organism from 48-hour-old agar cultures was sprayed on young plants of Black Zucchini squash as well as on cucumber plants. The sprayed plants were placed in a moist chamber overnight, after which they were transferred to a greenhouse bench at temperatures ranging from 70 to 80° F. To maintain humidity of the air, walks and benches were watered frequently. Included in the test were plants sprayed with distilled water and handled like the inoculated plants. Three days after the inoculation numerous small, water-soaked spots were observed underneath the leaves of the inoculated plants of both squash and cucumber. The checks showed no spots of any kind. Within five days, the inoculated plants showed medium-sized almost translucent spots, singly and in groups. Yellow zones were evident around dark spots on the squash leaves. Isolations from spots on both squash and cucumber produced the same organism as was originally isolated from field material. Greenhouse tests suggested the similarity of the squash organism to Pseudomonas lachrymans, the causal agent of the angular leaf spot of cucumbers. The squash isolant was compared bacteriologically with P. lachrymans isolated from cucumbers in California and with one isolant from Colorado. Since no physiological differences were detected between all the isolants used, it was concluded that the pathogen isolated from Black Zucchini squash was identical with P. lachrymans.

Inoculation tests with a squash isolant were positive on banana squash, watermelon, cucumber, honeydew melon, and muskmelon. Pseudomonas lachrymans from both Marketer and Black Diamond cucumbers produced typical lesions on Black Zucchini squash.

The occurrence of Pseudomonas lachrymans in squash as here presented appears to be the first case on record. It is quite possible that because in many cases field diagnosis is made on the basis of symptom pattern, the disease could be mistaken for the bacterial spot of squash caused by Xanthomonas cucurbitae. The two diseases are difficult to distinguish when they occur on cucumbers, as pointed out by Walker (5).

Summary

Bacterial leaf spot of Black Zucchini squash, occurring in the Colma area, near San Francisco, California, was determined to be caused by Pseudomonas lachrymans. With this organism, successful inoculation was obtained, under greenhouse conditions, on banana squash, cucumber, watermelon, honeydew melon, and muskmelon. This seems to be the first report of P. lachrymans on field-grown squash.

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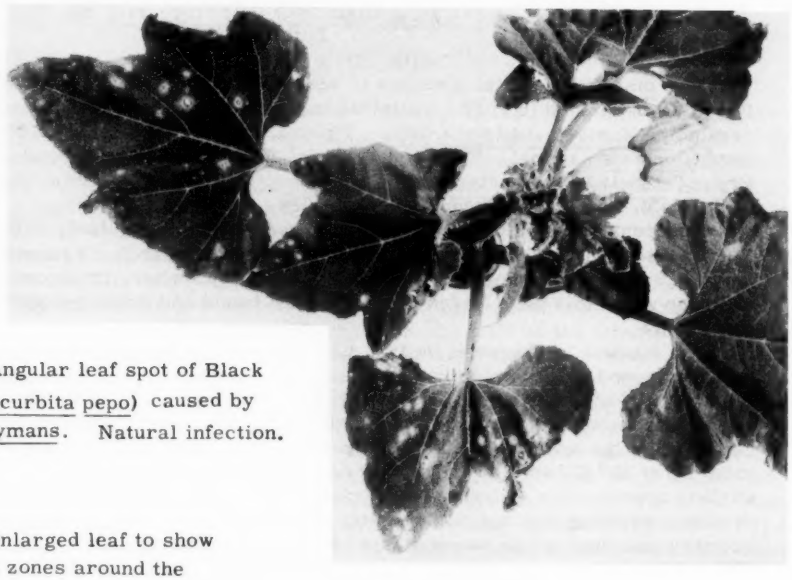
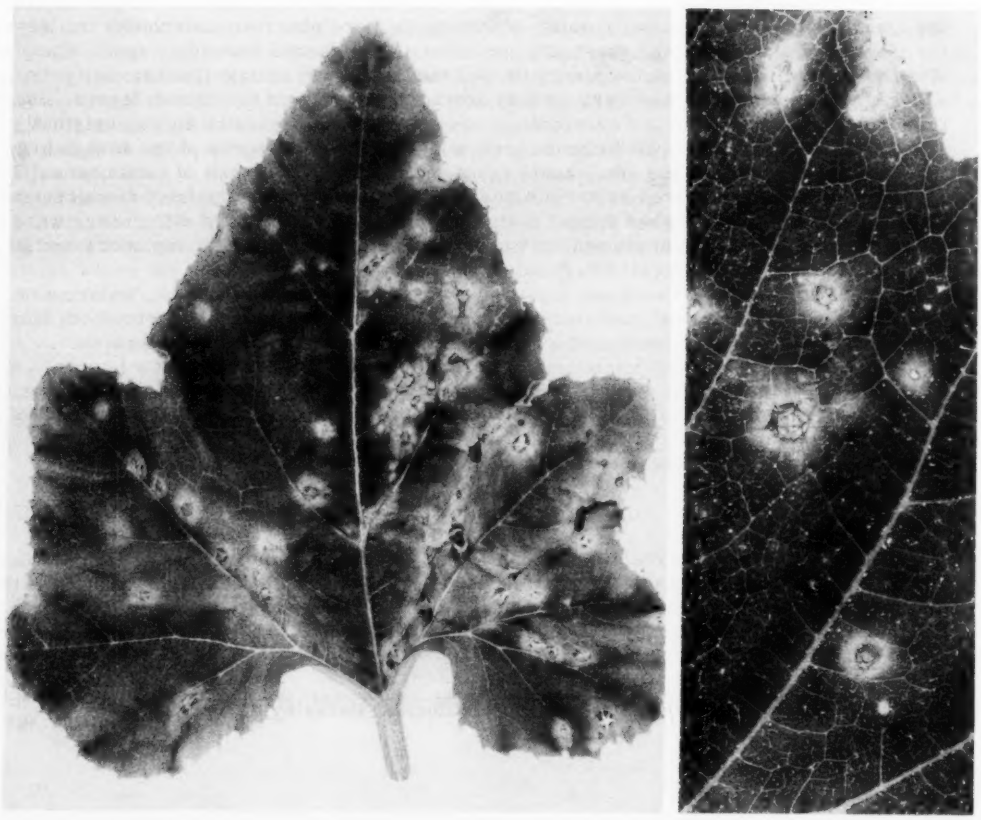


FIGURE 1. Angular leaf spot of Black Zucchini squash (Cucurbita pepo) caused by Pseudomonas lachrymans. Natural infection. Colma, California.

FIGURE 2. Enlarged leaf to show conspicuous yellow zones around the necrotic spots.



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USE OF PANOGEN DRENCH TO CONTROL DAMPING-OFF IN NURSERY FLATS

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Damping-off fungi, such as Rhizoctonia solani and Pythium ultimum, cause considerable damage to various nursery ornamentals when the plants are in the early seedling stages. These fungi are frequently present in various soil mixtures used in nursery practice. The trouble is especially severe where large amounts of leaf mold or peat are used as constituents. Although sterilization by steam or chloropicrin is helpful, these treatments render the soil unfit for immediate use because of temporary toxicity due to the alteration of organic constituents or slow dissipation of the gaseous sterilizing agent. In some instances, steam and gas sterilized soils become recontaminated by damping-off fungi which, because microbial competition has been destroyed in sterilization, may cause quite serious losses.

Panogen (methyl-mercury-dicyan-diamide) is one of the most active organic mercury compounds coming into use as a seed disinfectant. It is being used against Ustilago hordei, Helminthosporium gramineum, Tilletia tritici, T. foetida, Sphacelotheca sorghi, and many other fungi. Laboratory tests at the University of California showed its high toxicity against Rhizoctonia solani, Pythium ultimum, Fusarium solani f. cucurbitae, Verticillium albo-atrum, Botrytis cinerea, and Phytophthora cactorum. A great deal of the toxicity is due to the volatile nature of this chemical (Fig. 1). To demonstrate this property of Panogen, a suspension of the test organism was spread over potato-dextrose agar plates, the excess removed and plates uncovered, inverted and dried for 25 minutes at 37° C. Discs of filter paper (13 mm. in diameter) were soaked in various concentrations of the Panogen and placed on the under surface of the Petri dish covers. The inoculated surfaces of the agar were placed over the discs and the plates sealed with plasticine. The plates were incubated at 28° C. Figure 1 shows the absence of fungus growth in a circular area on the inoculated surface that was above the paper disc. Aeration of discs prepared by the above described method showed the chemical to be active even after two weeks exposure to the open air, thus demonstrating a very slow vaporization of the Panogen. This behavior of Panogen suggested its possible usefulness in combating damping-off in nursery soils high in leaf mold content.

Ground leaf mold known to cause considerable mortality in many species of greenhouse plants was obtained from one of the nurseries in the East Bay area of Alameda County, California. The leaf mold was placed in new sterilized pots provided with sterilized saucers. One set of six pots was drenched with Panogen 1:10,000, and another set of six pots was treated with distilled water. After 24 hours the pots were heavily seeded with Alyssum saxatile, which is especially susceptible to damping-off. Figure 2 shows complete protection of the plants obtained with the Panogen drench, whereas mortality in the untreated check was high. At the end of the experiment only a few plants remained in the untreated sets while the treated pots produced a normal quota of plants and were free of the disease. Pythium ultimum was recovered from affected plants in the check.

A nursery was selected where frequent occurrence of damping-off of numerous species of bedding plants had been observed in the flats. It was a general practice in this nursery to use almost pure ground leaf mold for seeding purposes. Considerable damping-off was in evidence in a large number of flats grown in the lath-house during the cold months of the year. Drenching of the leaf mold flats with Panogen 1:10,000, and 24 hours after the treatment planting of even the most susceptible species of plants, resulted in remarkable freedom from damping-off fungi, both Rhizoctonia solani and Pythium ultimum. The treatment was so encouraging that the grower substituted Panogen drench for his conventional methods of soil sterilization. This treatment seems to be devoid of any toxicity to the plants direct or residual. Seedlings showed considerable vigor and no injurious after-effects could be detected at any time from planting of the seeds to the eventual sale of the plants.

Seeds of the following plants were germinated safely and were free of damping-off fungi when planted in Panogen-treated, 1:10,000, leaf mold mix: Ageratum (Ageratum houstonianum), golden tuft (Alyssum saxatile and A. rostratum), aster (Callistephus, varieties American Beauty, Sunshine, and Pompon), begonia (Begonia semperflorens), marigold (Calendula

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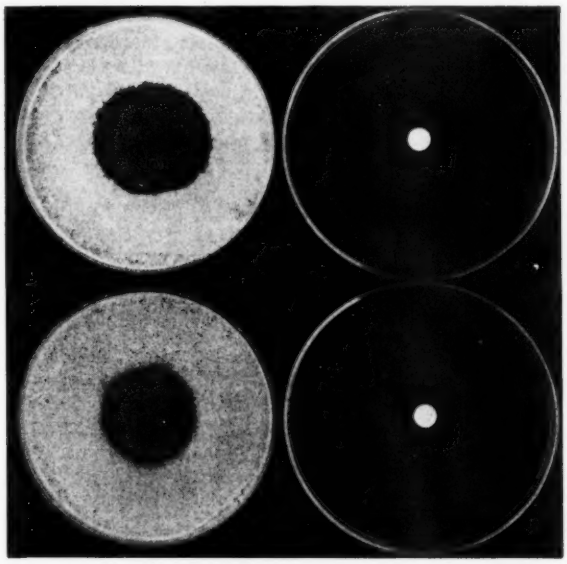

FIGURE 1. Inhibition of fungus growth by Panogen vapors. The cultures of Fusarium solani f. cucurbitae (left, above) and Verticillium albo-atrum (left, below) were inverted over the discs of filter paper (right) containing Panogen 1:10,000, which were dried separately before the experiment was performed.

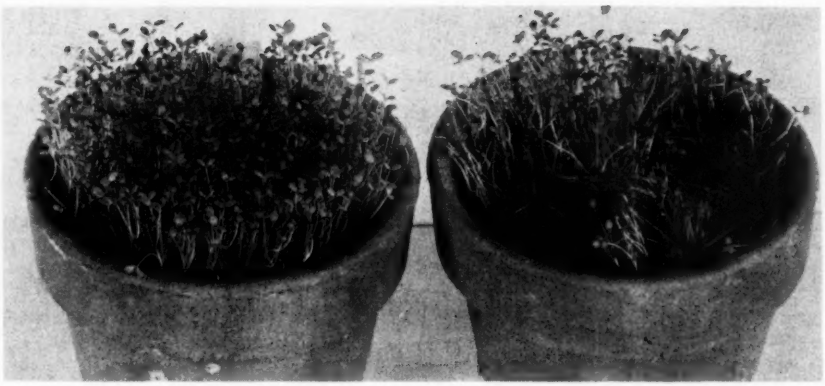

FIGURE 2. Control of damping-off in Alyssum, by Panogen drench 1: 10,000, (left) prior to seeding. Untreated check on the right.

officinalis), carnation (Dianthus caryophyllus), celosia (Celosia argentea), cineraria (Senecio cruentus), English daisy (Bellis perennis), forget-me-not (Myosotis scorpioides), lobelia (Lobelia erinus), nemesia (Nemesia strumosa), nicotiana (Nicotiana affinis), petunia (Petunia hybrida), phlox (Phlox drummondii), primrose (Primula polyantha) salvia (Salvia officinalis; and S. carduacea), butterfly-flower (Schizanthus pinnatus), snapdragon (Antirrhinum majus), verbena (Verbena hybrida), zinnia (Zinnia elegans), stock (Mathiola incana), bell pepper (Capsicum frutescens var. grossum), eggplant (Solanum melongena var. depressum), celery (Apium graveolens var. dulce), cauliflower (Brassica oleracea var. botrytis), and parsley (Petroselinum hortense).

Summary

Panogen (methyl-mercury-dicyan-diamide) showed considerable toxicity to damping-off fungi such as Rhizoctonia solani and Pythium ultimum. Owing to its slow volatility its action is prolonged. It produces no toxic effects on either seeds or plants in soil drenched with 1: 10,000 solution. Treated flats can be seeded 24 hours after the treatment. Many common species of ornamental and vegetable plants were free of damping-off when planted in a leaf mold mixture treated with Panogen.

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SOME IMPORTANT SOURCES OF CROWN GALL BACTERIA IN CALIFORNIA ORCHARDS

Peter A. Ark[1]

In a prune orchard where old prune trees had been pulled out because of bacterial gummosis and crown gall and a new planting made, a large number of Myrobalan 29C shoots were sprouting from the pieces of old roots left in the ground. The root pieces from which the volunteer shoots were growing had been buried to 10 inches and deeper. On lifting these roots with shoots it was found that on practically every one of the plants many large galls had developed at the cut places on the roots or stem made by the disc or plow (Figure 1). The galls were very active and undoubtedly were releasing large quantities of crown gall bacteria into the soil. Under such conditions newly planted trees are in constant danger of being inoculated with crown gall bacteria.

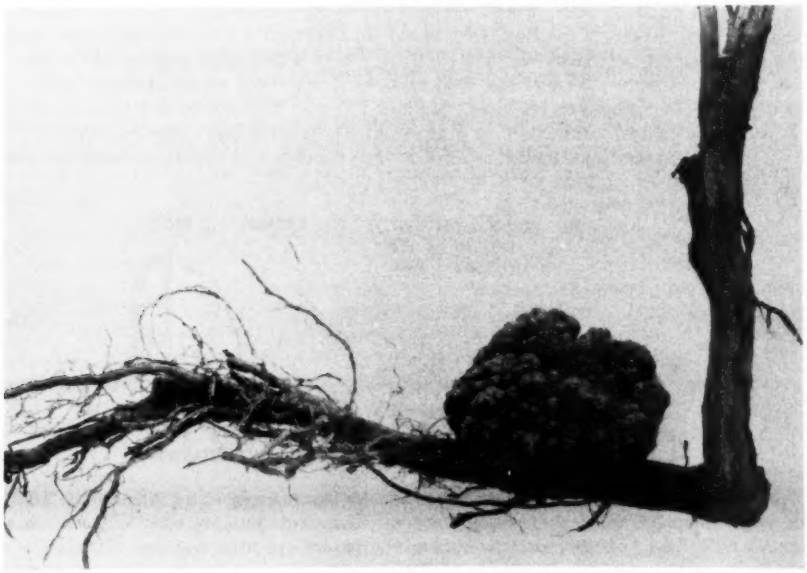

FIGURE 1. Volunteer Myrobalan 29C root stock with a large crown gall at the cut made by a disc. Found in a young replanted prune orchard where the old trees had been pulled out because of bacterial gummosis and crown gall, leaving roots like this which had been buried in the ground for six months after the trees had been pulled.

Crown gall is a serious problem in many peach, almond, and prune orchards in California and elsewhere. Although surgery and treatment with an Elgetol-Methanol solution can be successful in eliminating large galls found on the trunk or large roots near the trunk of the tree, the question of the appearance of new galls is of some concern to every grower. This is especially true in new plantings of peach and prune trees. It is common knowledge that in many orchards the presence of crown gall bacteria (Agrobacterium tumefaciens) is to be expected in the soil. However, maintaining the level of crown gall bacteria in a given orchard depends on cultural practices. Deep discing and the number of galls already present in an orchard determine to a great degree the potential reservoir of crown gall. Constant reinoculation of roots, by contaminated discs or other implements used, may lead to a very substantial increase of crown gall in a young orchard, making subsequent elimination from the trees practically impossible. The soil under such conditions can become heavily contaminated with crown gall

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bacteria from numerous galls on roots and thence to new roots through man-made wounds. Where a situation like this exists and the trees have to be lifted, more attention should be given to a thorough job of eliminating most of the remaining roots, especially those of stocks which can start new plants and remain alive for years. Cropping for several years to non-susceptible plants before replanting is highly desirable.

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THE EFFECT OF CAPTAN[1] ON GRAY MOLD ROT INCIDENCE AND YIELD OF STRAWBERRY

Dwight Powell

It has been demonstrated that certain fungicides will greatly decrease the gray mold rot (Botrytis cinerea) infections of strawberry (1, 2). Such experiments have been conducted primarily with small, replicated plots. It has been obvious that spores of the fungus would be disseminated from the untreated plots over the entire bed during the first and second picking thus reducing the apparent effectiveness of the fungicide treatments. This year a rather large patch of approximately two acres was treated, while three unsprayed rows on each side served as checks. It was hoped that the control obtained could thus be more accurately measured.

Methods: A three-year-old planting of Blakemore strawberries arranged in 16 rows 1500 feet long was selected for this test. The center 10 rows were sprayed with captan (50%) at a concentration of 8 pounds in 100 gallons of water and 3 rows on each side were not sprayed. The fungicide was applied with a five-nozzle boom attached horizontally to the rear of a sprayer equipped with a 150-gallon tank and a 7-gallon-per-minute hydraulic pump set at 200 pounds pressure. The nozzles, each having a 3/64 inch disc aperature, were 10 inches apart on the 40-inch boom so that the width of 1 row (42 inches) could be covered with one trip through the patch. Driving speed was regulated so as to apply 5 to 7 pounds of 50% captan an acre. Insecticides were omitted in order to evaluate better the fungicide treatment.

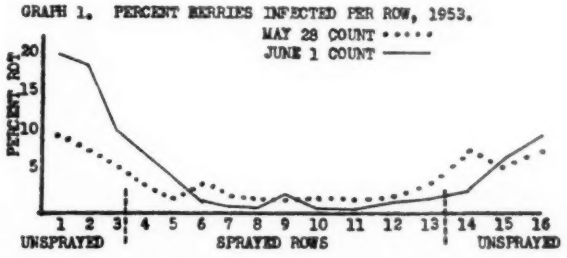

FIGURE 1. Build-up of gray mold on treated rows adjoining untreated rows. Counts made May 28 and June 1. The general increase between these two dates followed the equivalent of 1/2 inch of rainfall applied with sprinkler irrigation equipment May 29. Fungicide treatment held infection in the center 6 rows to a fairly low level up to June 1. Rows 4, 5, and 13 show definite effects from proximity to unsprayed rows. Irrigation more than doubled infection of rows 1 to 3, with no increase in center treated rows.

Five applications were made during the preharvest period as follows: April 14, early bloom; April 28, early bloom; May 6, full bloom; May 12, first maturing berries; May 19, five days before the first picking. The amounts of 50% captan used per acre per application were 6.6, 5.0, 7.0, 6.0, and 6.0 pounds, respectively. One more spray than would normally be required was applied after sub-freezing temperatures April 17, 18, and 19 destroyed the early blossoms and thus delayed the first picking about two weeks.

Results: The early observations for the degree of gray mold infection are recorded in Table 1.

It is evident from these data that the treatment was effectively reducing the amount of gray mold infection. It is also interesting that the degree of infection varied considerably from one end of the patch to the other. This condition seems to be characteristic of this disease and may reflect the amount of inoculum carried over from the previous season. Blossom infection is likely to be a more important factor than fruit infection during a dry spring. There is always sufficient rainfall in the early spring in Illinois to cause blossom infections but frequently a dry period occurs just prior to or during harvest and fruit infection then may not be alarming.

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[1] A coined name for N-trichloromethylthio tetrahydrophthalimide.

Table 1. The extent of gray mold infection May 12 and 22.

Location in patch	Number of clusters infected among 500 per plot, May 12		Percent berries infected among 500 per plot, May 22	
	Treatment	No treatment	Treatment	No treatment
East end	6	20	4.0	13.0
Middle	5	19	0.5	9.6
West end	2	3	0.0	6.5

Table 2. Yield record in crates per row.

Dates of picking	Yield in crates per row		Percent increase
	Treatment	No treatment	
May 24	3.4	2.0	70.
May 26	8.9	5.0	78.
May 28	3.4	2.0	70.
June 1	5.7	3.0	90.
Total	21.4	12.0	78.
Per acre yield	193.0	109.0	78.

The data in Table 2 show that captan definitely increased production. Many factors could be responsible for an increased yield. Since the check manifested approximately 75% more gray mold infection than the treated plot, disease control was certainly an important factor. Horn (1) showed that captan gave a greater increase in yield than other fungicides used in his test and also noted that captan sprayed plants "seemed more vigorous than the controls." Observations on June 3 indicated that the plants had benefited nutritionally from the captan and that fruit size was increased. For example, from 8 quarts of berries picked at random from the sprayed and unsprayed rows, the treated berries averaged 92 berries per quart as compared to 123 per quart from the untreated rows.

Additional evidence that captan will increase production was reported recently, in correspondence, by W. D. Armstrong, Horticulturist, Kentucky Agricultural Experiment Station, Princeton, Kentucky. He used three sprays of captan at approximately ten-day intervals on a one-year-old bed, and harvested 236 crates per acre from the treated plot as compared to 158 from the control. On a two-year bed he harvested 157 crates per acre from the treated and 146 from the untreated plants. Disease data were not collected from the Kentucky plots. Mr. Armstrong suggests an explanation for the considerable difference between the results in these two patches. The first year planting had been somewhat over-fertilized and growth was very tall and vigorous, resulting in a condition conducive to rot. It was encouraging that under these circumstances the captan sprays gave an outstanding increase in production. The second year patch was less vigorous, with lower foliage and more widely spaced plants and consequently less shade, so that there was less tendency for the berries to rot even in the non-sprayed area. Hence, the captan sprays were less advantageous.

To determine the effect of field fungicide applications on post harvest infection, berries were picked from each plot and placed in common storage for 48 hours. After this period 26 of 777 berries from the treated rows, or 3.3 percent, showed gray mold, as compared with 131 of 985 berries, or 13.3 percent, from the untreated rows. Thus, berries are given substantial post-harvest protection by field treatments with captan.

Summary: Five applications of 50% captan at 6- to 10-day intervals, starting with the appear-

ance of the first bloom, decreased gray mold infection of the blossoms and fruit approximately 75 percent. Production was increased from 109 to 193 crates per acre. On June 3, after the fourth picking, captan-sprayed berries averaged 92 per quart as compared to 123 per quart for the untreated fruits. Captan delayed the development of post-harvest rot.

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NITIDULID BEETLES RELEASED 500 FEET AWAY REINFEST OAK WILT FUNGUS MATS

John S. Boyce, Jr.[1]

A limited attempt was made to determine whether nitidulid beetles (Nitidulidae) are attracted to mats of the oak wilt fungus Endoconidiophora fagacearum over distances up to 500 feet. Several considerations prompted the test.

Nitidulids are commonly found on mats of the wilt fungus. It has been demonstrated that these beetles can inoculate healthy oaks with spores of Endoconidiophora fagacearum when caged on fresh wounds (1, 3). Nitidulids have been suggested as one means by which mats may be spermatized to initiate ascospore production (2).

Numerous nitidulids were found on fresh mats on a single, felled oak wilt-diseased tree at Junaluska, North Carolina, beginning in October 1953. Some mats bore fertile perithecia on October 22, and all mats exposed at this time were removed from the tree and destroyed. Fresh mats that had neither perithecia nor visible perithecial fundaments on them when they were examined on November 2, produced fertile perithecia four days after they were brought into the laboratory where temperatures were higher. The formation of these perithecia and the fact that all mats had previously been removed from the tree suggested either that the mats were spermatized from an outside source before they were collected, or that they consisted of thalli of both compatibility types.

Tissue cultures were made from the wood beneath five mats with perithecia. The isolates were self-sterile, indicating that only one compatibility type of the fungus was present in each mat prior to spermatization. Each isolate was then crossed with every other tissue isolate from this tree, including several from mats without perithecia, and again perithecia were not formed. It was concluded that all of the mats from which isolates were obtained probably consisted of the same compatibility type.

The fact that some mats were spermatized suggested that vectors, possibly including nitidulids, carried spores of opposite compatibility type to the mats on this tree. The tree was found August 14, 1953, during an aerial survey. The closest wilting oaks discovered during the summer were three-fourths of a mile away. Mats which formed on two of these trees early in September were largely decomposed on October 7, at which time they were destroyed. It is not likely that they supplied material for the spermatizings early in November.

It is possible that the spores that functioned as male cells were produced on other wilting oaks in the vicinity, that were overlooked, although none were known. However, the observations suggest that vectors spermatized the mats after traveling considerable distances. Consequently, it became of interest to know over what distances nitidulids are attracted to mats of the oak wilt fungus.

Table 1. Recovery of marked nitidulids on mats of Endoconidiophora fagacearum, 1953

Release point	Nitidulids released	Release period	Nitidulids recovered	Date recovered
Feet	Number		Number	
100	27	Nov. 17-Nov. 20	1	Nov. 20
			1	Nov. 25
			1	Nov. 30
			1	Dec. 3
500	114	Nov. 17-Dec. 3	2	Dec. 7
			2	Dec. 11
Both	141		8	

[1]The author is grateful to G. H. Hepting for suggesting the approach to the study; to C. F. Speers for his suggestions on handling the beetles; and to H. J. Duncan for his assistance in the field.

Nitidulids were collected for marking by temporarily removing the bark above 14 fresh mats on the Junaluska tree during each inspection and then replacing it. The beetles were marked by placing small amounts of melted wax from coloring crayons on their elytra. They were released at points 100 feet and 500 feet from the tree. An additional 11 mats were included in the examinations beginning November 30. The mats were examined at intervals of 1 to 3 days from November 17 to December 16.

Table 1 shows that several marked nitidulids returned to mats from distances of 100 feet and 500 feet.

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POTENTIAL DANGER TO THE PERSIAN WALNUTS, DOUGLAS-FIR, AND PORT ORFORD CEDAR OF THE PACIFIC COAST FROM THE CINNAMON PHYTOPHTHORA

G. Flippo Gravatt

Among our invading fungi from abroad (7) few have produced such widespread destruction as the cinnamon fungus, Phytophthora cinnamomi, the cause of root diseases on innumerable hosts. This fungus was originally described from Sumatra on the cinnamon tree. In retrospect it appears that this fungus first came into the United States more than a hundred years ago, when the extensive native chestnut growth of our Southeast started dying from an unknown root trouble. Numerous old records testify to the steady spread of the disease in ten States, from Maryland to Arkansas. Millions of acres of chestnut growth was destroyed and various species of chinkapins (Castanea) also were seriously affected. The writer did field work on this disease and chestnut blight in the South at intervals between 1912 and 1945, saw the evidence of an invading organism, and heard the same story of progressive dying of chestnut again and again, from old inhabitants (3, 6). The Asiatic chestnut blight fungus, Endothia parasitica, swept southward from New York, its point of initial entry into the United States, at a very much more rapid rate than the cinnamon fungus spread northward and in 50 years met the cinnamon fungus and completed the destruction of the American chestnut and most of the chinkapins.

In the Southeast the cinnamon fungus is now credited with being the primary cause of the little leaf disease of shortleaf pine, Pinus echinata, and loblolly pine, Pinus taeda, on some five million acreas of forest land (2). It attacks only the very small roots of these pines under certain soil aeration conditions whereas it attacks both small and large roots of chestnut and even invades the crown. Azalea, rhododendron, box, walnut and other species are attacked in the Southeast and even as far north as New Jersey the cinnamon fungus kills rhododendron. The fungus seems to be definitely limited in its northward spread by colder temperatures, and this same limitation on its northward spread exists in Europe. A detailed article on the world-wide spread of this fungus by the writer and Bowen Crandall is in preparation.

The chestnut trees of southern Europe have been attacked by the cinnamon fungus, the time sequence being much the same as in our Southern States. The evidence is very strongly indicative that on both continents infected plants of an undetermined kind which started the epidemics were introduced over a hundred years ago. The first reports of dying chestnuts were from Portugal and Spain and later ones were from other countries, from England westward to the Caucasus Mountains of Russia and Turkey in Asia Minor. The writer, in 1950, 1951 and 1953, visited numerous chestnut areas from England and Portugal west to Turkey in Asia Minor and saw the continuing destruction of the chestnut by the cinnamon fungus. Foresters and others in various areas discussed with him the steady spread of the disease across valleys and up mountains. The Asiatic chestnut blight, reported in Italy in 1938, has now spread into Switzerland and Yugoslavia and threatens to complete the destruction of the European chestnut as it did that of the American chestnut in the United States (5).

In southern Europe the Persian (English) walnut, Juglans regia, was formerly a much more important crop than it is at present. In France, for instance, the production of walnuts is now about one-third as much as it was 60 years ago. Several factors tended to reduce the number of producing walnut trees, but the most important was dying of the trees. Within the last few years certain French pathologists have become convinced that the cinnamon fungus is the primary cause of the decline and death of the walnut trees in that country (4, 9). The affected regions are primarily the same as those in which the chestnut has been killed by this fungus. Pathologists in other European countries have also reported the cinnamon fungus on walnut.

In the eastern United States the susceptibility of nursery trees of Persian and black walnuts, Juglans regia and J. nigra, to the cinnamon fungus under conditions favorable for the parasite was reported (3). The susceptibility of the walnuts was shown also by inoculation with isolates from different hosts. In a recent bulletin from Oregon (11) the Persian walnut is listed as susceptible to the cinnamon fungus on the basis of inoculations made in that State. Paul W. Miller is working on the possible relation of this fungus to the undetermined dying of walnuts in a few Oregon orchards. Most of the walnuts now being planted in Oregon have the susceptible Persian walnut as rootstocks.

Two forest trees of the Pacific Coast are seriously threatened if spread of the cinnamon fungus continues. In 1945 it was reported that nursery plants of Douglas-fir, Pseudotsuga

menziesii, inoculated with isolates of this fungus from different hosts from three States were "highly susceptible" to the disease (3). Pimentel (8) reported in 1945 that Douglas-fir plantings were attacked naturally by this fungus in Portugal. D. C. Torgeson found 13 of 14 different isolates from 9 different hosts from 5 different States and Hawaii pathogenic to Douglas-fir seedlings in greenhouse tests at Corvallis (1).

The Port Orford cedar, Chamaecyparis lawsoniana, or Lawson cypress as it is known to nurserymen, has been seriously attacked by the cinnamon fungus in a number of localities in Oregon (11). It was first found on young plants of this host in Oregon in 1950. There is no doubt about the virulence of this fungus on Port Orford cedar, shown by the way in which it spread through an ornamental planting and by inoculations on numerous strains or varieties of this species. Another species of Phytophthora, P. lateralis, also is parasitic on the Port Orford cedar and the symptoms caused by the two fungi are much the same.

In the Pacific Northwest there are some 20 million acres of Port Orford cedar and Douglas-fir with a total stand of 400 billion board feet. These trees grow mostly in dense stands with closely interlacing roots, thus making ideal conditions for progressive spread of the cinnamon fungus if it gets into the native stands. We know the high susceptibility of nursery and small planted trees of these two tree species to this fungus. What the outcome will be if the fungus should become widely distributed in the native stands of these species is not known. We also know about the damage caused to Persian walnut orchards in Europe by this fungus, but what it will do in our walnut orchards on the West Coast is not known. Once the cinnamon fungus became widely distributed in forest and orchard soils there might be no practical way of handling the situation.

Of course there is a possibility that the fungus may be limited by low temperature at the higher elevations, but the development of the disease under the climatic conditions in New Jersey and in England makes this factor questionable. Types of soil, aeration, and microbiological activities may limit its spread, but on highly susceptible hosts these factors may not be of much importance. Moisture and aeration have great effect on the parasitism of the fungus on some hosts. A soil organism like the cinnamon fungus without aerially spread spores may progress in native growth rather slowly, but on native chestnuts this fungus moved all too rapidly.

Thorn and Zentmyer (10) just summarized the hosts of Phytophthora cinnamomi and mentioned the first report of this fungus on the Pacific Coast in 1942 by V. A. Wager. The fungus is evidently prevalent in southern California, but these authors did not list it as present in walnut orchards or in the native forest growth of Douglas-fir or Port Orford cedar. The Oregon authorities made a very significant statement about the cinnamon fungus on page 15 of the Northwest Forest Pest Action Committee Report (1) as follows: "Its present distribution appears limited only by its recent introduction".

The Bureau of Nursery Service of the Oregon State Department of Agriculture has taken energetic steps in an attempt to prevent further spread of the cinnamon fungus in Oregon nurseries. Nursery shipments and the secondary spread from such plantings are the principal means by which the fungus may reach orchard and forest soils. There should be a conference of state and government authorities with commercial orchard and forest interests involved to determine what further steps are needed.

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FOMES ANNOSUS ON SLASH PINE

W. A. Campbell and G. H. Hepting

Fomes annosus is a widely distributed root-killing fungus that attacks a variety of coniferous hosts. Haasis (2), in 1923, reported its occurrence on white pine (Pinus strobus) in western North Carolina. Hepting and Downs (3) noted the relationship between thinnings and the amount of root and butt rot in the stands in which Haasis first found the disease. Eastern redcedar (Juniperus virginiana) is a common host for F. annosus in the southern Piedmont (1). Trees of all sizes are attacked and killed. Although the fungus fruits commonly on stumps of shortleaf pine (P. echinata) and loblolly pine (P. taeda), it has not been reported as parasitic on these species. However, the buildup of the fungus population on stumps of these species is credited with the spread of root rot among redcedars.

Recent observations by Roth (4) and Toole and Boyce (5) demonstrate that pitch pine (P. rigida) and Atlantic white cedar (Chamaecyparis thyoides) are susceptible to attack.

In 1952 the South Carolina Forestry Commission reported root decay and some windthrow in a rapidly growing 15-year-old slash pine (P. elliotti) plantation on the Manchester State Forest near Wedgewood. F. annosus was isolated from the decayed roots. Considerable cambial killing at the ground line was also observed on a number of trees.

This indication that Fomes annosus may actively attack slash pine is a matter of concern. In recent years this species has been planted on thousands of acres in the South, and, under fire protection, has reseeded naturally over large areas. Many natural and planted stands are now being thinned, thus providing conditions known to favor the intensification and spread of root rot.

An indication that such thinnings may serve to spread root rot in slash pine has been found in a 15- to 20-year-old natural stand near Swainsboro, Georgia. For the past three years the owners have observed dying in this stand and this dying followed a thinning made five years ago. A number of trees have died each year, the most recent mortality occurring late in the summer of 1953. That the dying will continue is attested by a group of trees in poor condition that show streaks of rot on the larger roots or at the root collar. Abundant fruiting of F. annosus was found in the duff adjacent to the dead trees or attached to the roots and stumps just below the soil line.

These two examples of injury by F. annosus on slash pine suggest the possibility that the fungus may someday become a factor in the management of this species, as it is in so many coniferous plantations in Europe. Further observations are needed to determine the relative prevalence of the fungus in slash pine stands and the effect of thinnings and partial cuttings upon the residual trees.

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DISEASE OBSERVATIONS ON CASTORBEANS IN 1953

D. Donald Poole

Introduction

Attempts have been made since the late 1800's to grow castorbeans (Ricinus communis L.) in various parts of the United States. Although over 150 different diseases have been reported on castorbeans from various countries in the world (5), relatively few have had any influence on the production in the United States. About the time of World War I, gray mold (Sclerotinia ricini Godfrey) was observed as a serious disease of castorbeans in plantings in the Gulf Coast area (3). The threat of this disease up to the present time has prohibited growing castorbeans in the southeastern States. Serious losses from Alternaria leaf spot and capsule mold have also occurred in the past few years (6) in humid regions of the southern and eastern United States and, on occasion, in arid sections of the Southwest during periods of high relative humidity.

Since the initiation of large scale production in 1949, substantial acreages have been planted in Arkansas, Oklahoma, Texas, Arizona, and California. In general, production in these States has been relatively unaffected with diseases. Alternaria leaf spot and capsule mold, however, has been particularly destructive in some sections of Arizona, Arkansas, Texas, and Oklahoma after periods of high rainfall or high relative humidity. To date, however, no serious diseases have been reported from the California production area.

Bacterial Leaf Spot

Calvert et al (1) reported the occurrence during the 1952 season, of a new bacterial pathogen, Xanthomonas ricinicola (Elliott) Dowson, on castorbeans in the United States for the first time. This initial report consisted of a description of the organism, its cultural characteristics and of observations in variety tests at Beltsville, Maryland, College Station, Texas, and on increase fields of Nebraska 145-4 at Jones, Oklahoma.

Castorbeans were grown on over 100,000 acres in Texas and Oklahoma in 1953. Nearly 75 percent of this acreage was planted to the Conner variety which is susceptible to bacterial leaf spot. Surveys made during the 1953 growing season revealed 66 counties in Texas and 12 in Oklahoma in which the disease was found. The disease reached almost epiphytotic proportions in some areas of southern and eastern Texas and south-central Oklahoma and serious losses occurred. The pathogen was also present in the High Plains production area of Texas, causing serious damage in some cases. Variety observation plots planted in Louisiana, Alabama, Maryland, and two locations in Florida revealed the presence of the pathogen in every instance.

Most of the losses that occur from this disease result from heavy leaf infection and defoliation, blasting of immature racemes and the breaking over of racemes and stems caused by girdling of the parts affected. Symptoms of leaf infection are readily recognizable as small, water-soaked spots on the leaf that later turn dark, chocolate brown. Shriveling and "drooping" of the leaf blade and the formation of water-soaked cankers on the petioles, immature racemes and stems are all symptoms of the later, more serious stages of the disease. In most cases, these stages appear within a week after heavy dews or rains and tend to subside during the drier periods.

It is difficult to estimate the extent of actual losses. In some fields of Conner in southern and eastern Texas and south-central Oklahoma, almost all of the first and second racemes were lost. Since the first two racemes constitute about one-half of the crop, it seems probable that a 40 to 50 percent loss was suffered in some fields. Losses up to 50 percent of the total leaf area, and premature defoliation probably add from 1 to 5 percent to the crop loss. In the Conner producing areas of Texas and Oklahoma it was estimated that an average of 25 percent of the 1953 crop was lost from bacterial leaf spot.

In all locations observed, the variety Cimarron appeared to be the only strain carrying any form of functional resistance. Varieties Nebraska 145-4, Conner, and USDA 367 appeared to be the most susceptible strains in most plantings. USDA 74, USDA 101, Western Oilseeds Hybrids 4, 7, 9, and 10, Baker 195, Nebraska 224A-1-6-4-3, Illinois 48-84, and Illinois 48-36 appeared to be intermediate in reaction. All hybrids containing Nebraska 145-4 as the female parent were susceptible to bacterial leaf spot. Of these, N145-4 x USDA 101, N145-4 x Cimarron, and N145 x Illinois 48-84 appeared to be most susceptible. Nebraska 145-4 x

Illinois 48-36 and N145-4 x USDA 74 were also susceptible, however, to a lesser degree.

Nebraska 145-4, the most common female parent in present commercial hybrids, is extremely susceptible to bacterial leaf spot. In view of the fact that this disease can be seed-borne (1), extreme caution should be observed to insure that seed production fields are disease-free.

Alternaria Leaf Spot

Second in order of importance of castorbean diseases in present production areas are leaf spot and capsule mold caused by Alternaria ricini (Yoshii) Hansford. The leaf spot stage of this disease appeared at some time during the season in all castorbean fields inspected in 1953.

Alternaria blight is mainly a late-season disease of mature castorbean plants, although Stevenson (7) reported that A. ricini was a serious seedling disease at Beltsville, Maryland in 1947. This disease is usually first visible on the lower, older leaves of the plant as light brown lesions made up of a series of concentric rings around the point of infection. As the season progresses the pathogen may, under humid conditions, attack the green capsules on the raceme causing serious losses. At maturity the entire raceme may take on a sooty, black appearance from a great abundance of spores. Infection of the mature seed sometimes occurs if the seed is not harvested soon after ripening. Such seed is often killed and the resulting "pops" are a loss to the grower.

Losses due to this disease were very noticeable in some areas. Several fields in eastern Texas had losses from capsule mold in 1953 running as high as 10 to 25 percent. Serious capsule mold damage was also noted in Virginia. It is difficult to estimate true losses since many of the "pops" were still heavy enough to carry over with the good beans and appear normal. This disease also did some damage, mainly as a leaf spot, in the Rolling and High Plains areas of Texas. Limited observations in Texas indicated that the variety Cimarron is resistant to the disease.

Cotton Root Rot

Several observations of cotton root rot, Phymatotrichum omnivorum, on castorbeans were noted in fields in central Texas on Houston clay soil in 1953. These limited observations gave no indication of any varietal resistance. Castorbeans were reported as a susceptible host of cotton root rot as early as 1929 (4). This disease is of minor importance at present, since acreages on soils of the Houston series are small and plantings are on a trial basis.

Southern Blight

Isolated spots of southern blight, Sclerotium rolfsii, were found in many castorbean fields. The disease was not general in any of the fields observed. Plants showing symptoms were in all cases confined to small spots and little loss occurred.

Gray Mold

Gray mold, Sclerotinia ricini, is of little importance in present production areas. Variety observation plots at Gainesville, Florida, and Houma, Louisiana, showed some gray mold in 1953. In the plots at Gainesville, gray mold appeared to be the most serious disease. There is evidently no immunity to gray mold in present commercial varieties. There does, however, appear to be some resistance in Illinois 48-36, N145-4 x Illinois 48-84 hybrid, N145-4 x Illinois 48-36 hybrid, USDA 367, and Nebraska 224A-1-6-4-3.

This disease apparently becomes a problem only under extremely warm, humid conditions. Under such conditions the pathogen expresses itself in the form of the imperfect stage, Botrytis. It grows on the green capsules of the raceme, enters and finally destroys them.

Miscellaneous Diseases

A new as yet unidentified virus-like malady was observed in a number of localities in Texas and Oklahoma in 1953. Symptoms first appeared in early stages of growth as crinkled leaves and somewhat stunted plants. Attempts to transmit the trouble both mechanically and by grafting have been unsuccessful. Thrips were found associated with malformed plants in northwest Texas. In most fields the plants revived and grew out of the condition later in the season.

Isolation of a Cercospora sp. was made by Earhart (2) from plants in an observation test at Gainesville, Florida in 1953. This isolation was made from blasted racemes of several varieties. To date no reports of this organism have come in from other locations.

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FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE AND THE TEXAS AGRICULTURAL EXPERIMENT STATION

ALFALFA - A COMMON HOST FOR THE WILT FUSARIA FROM ALFALFA, COTTON, AND CASSIA

G. M. Armstrong and Joanne K. Armstrong

When alfalfa wilt Fusaria were obtained in 1949[1] and 1951[2] for cross-inoculation experiments in the greenhouse, it was quickly discovered that at least three different forms will cause wilting of alfalfa. For the present, these forms will be designated as the alfalfa, cotton, and cassia wilt Fusaria, respectively. The cotton wilt isolates reported here are restricted to those collected in the United States. The cassia wilt Fusarium, which was first collected in South Carolina in 1946 and in Georgia in 1948, is new and has not been described. It is different from the one mentioned by Armstrong et al.[3], which was the cotton wilt Fusarium.

Most of the plants were grown in steamed sand in 2-gallon glazed pots and were inoculated by cutting the roots on one side and pouring a three-day-old liquid culture of the fungus around them. Details of the method (Method A) have been described[4]. The medium for the inoculum was as follows: sucrose or dextrose 2%1 $MgSO_4$, 0.003M; KCl, 0.022M; KH_2PO_4, 0.008M[5]; $Ca(NO_3)_2$; 0.0356M[5]; $FeCl_3$, $MnSO_4$ and $ZnSO_4$, 0.2 p.p.m. each of cations. Single spore lines, the pathogenicity of which had recently been proven, were used in the inoculations.

In greenhouse tests, the alfalfa wilt Fusarium was highly pathogenic to Grimm and Kansas Common alfalfa, but no wilting occurred when it was used to inoculate plants of 36 different crops or varieties of crops including Cassia tora L., Gossypium hirsutum L., G. barbadense L., G. arboreum L., and G. herbaceum L. Furthermore, no external symptoms of wilt were observed when either Grimm or Kansas Common alfalfa was inoculated with 26 different wilt Fusaria other than those from alfalfa, U.S.A. cotton, and cassia, although in some cases a few plants showed slight internal discoloration.

Similar inoculations with the Cassia Fusarium showed that it was highly pathogenic to cassia, slightly less so to alfalfa, but mildly or not at all pathogenic to cotton. Some of the 24 isolates tested caused no wilting of Rowden cotton, others caused mild symptoms chiefly in a few lower leaves, but three of the isolates caused severe wilt of some of the plants.

Seventeen different cotton wilt isolates from seven States were used in the greenhouse inoculations. All caused high percentages of wilt of Rowden cotton and of Grimm or Kansas Common alfalfa. Most of the isolates produced no external symptoms of wilt in cassia, a few were weakly pathogenic, while two were exceptional in that they caused severe wilt of some cassia plants.

In addition to Grimm and Kansas Common, eight other varieties of alfalfa have been included in pot tests in steamed sand with the wilt Fusaria from alfalfa, cotton, and cassia. Some plants of all varieties wilted, but further tests with larger numbers of plants will be necessary to determine whether the variations among the eight varieties in percentages of wilted plants are significant.

It is evident that alfalfa is a common host for the alfalfa, cotton, and cassia wilt Fusaria, but that each Fusarium is different in pathogenicity.

In March 1951, a plot of alfalfa was started in a field heavily infested with the cotton wilt Fusarium, and soil from this plot was also used for alfalfa in the greenhouse. Fourteen varieties of alfalfa were planted in 10-foot rows 12 inches apart in 4 randomized blocks in the field. The seeding rate was heavy, and very thick stands were secured. Much of the 1951 growing season was hot and dry, and no cuttings of the plants were made. Irregular inspections of the plots showed that some plants were dying but fewer than was to be expected from the results of the inoculations in the greenhouse. Some wilted plants were plated and the Fusarium isolates obtained proved to be the cotton wilt organism in subsequent inoculation tests.

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[1]Courtesy Dr. C. L. Lefebvre, Beltsville, Maryland.

[2]Courtesy Dr. K. W. Kreitlow, Beltsville, Maryland.

[3]Armstrong, G. M., B. S. Hawkins, and C. C. Bennett. 1942. Cross inoculations with isolates of Fusaria from cotton, tobacco, and certain other plants subject to wilt. Phytopath. 32: 685-698.

[4]Armstrong, G. M., and Joanne K. Armstrong. 1948. Nonsusceptible hosts as carriers of wilt Fusaria. Phytopath. 38: 808-826.

[5]Misprint in Phytopath. 1948. 38: 809 where these salts were 0.1008M and 0.10356M, respectively.

Observations in March 1952 indicated that the number of missing plants was greatest in the rows of Orestan and Nemestan varieties. At the present time, these varieties are still the most depleted in stand.

Since killing of alfalfa in the field in 1951 was less severe than expected, in January 1952 soil from this cotton wilt field was placed in 2-gallon glazed pots and brought to the greenhouse. Orestan and Grimm alfalfa and Rowden cotton were planted in the pots. By November 1952, when the experiment was terminated, all the cotton plants had wilted, and 60 percent of the Orestan plants and 38.4 percent of the Grimm plants had shown external symptoms of wilt.

These pot and field tests indicate that the cotton wilt Fusarium can be an important factor in depleting the stand of alfalfa. A full account of the investigations has been prepared for publication elsewhere.

DEPARTMENT OF BOTANY AND BACTERIOLOGY, SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN COOPERATION WITH THE FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE

REDUCTION IN YIELD OF COTTON CAUSED BY DISEASES IN 1953

Compiled by the Cotton Disease Council's Committee on Disease Losses, Philip J. Leyendecker, Chairman.

The Committee received estimates from 47 cotton specialists across the belt. The condensed report was compiled utilizing the same methods as in 1952 (PDR 37: 175-177). However, this year the estimates have been sub-divided into parasitic and non-parasitic diseases. A number of co-operators have expressed the opinion that nutrient deficiencies should be eliminated from our estimates as they are primarily problems for agronomists and soil chemists. This view is well taken and it is suggested that consideration be given to this point at the 1953 meeting of the Council.

Considerable interest has also been expressed by cooperators concerning the use of a uniform method of reporting disease losses. The Committee feels that this problem is the next order of business for the Council and it is hoped that a preliminary plan can be worked out during the 1953 meeting.

The Committee again wishes to thank all who so generously gave their time by contributing to the Committee report. Suggestions which were offered by the contributors to increase the value of the loss estimates will be presented to the Council for consideration.

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ESTIMATED PERCENTAGES OF REDUCTION IN 1953 COTTON YIELD CAUSED BY DISEASE

Diseases	Calif.	Ariz.	N. Mex.	Tex.	Okla.	Mo.	Ark.	La.	Miss.	Ala.	Ga.	S.C.	N.C.	Tenn.	Total percent loss	Total bales lost
I. PARASITIC																
1. FUSARIUM WILT F. vasinfectum	0	0	0	.03	Tr	3.5	2.2	1.5	4.0	1.0	3.5	2.0	2.0	1.7	1.36	256,253
2. VERTICILLIUM WILT V. albo-atrum	13.0	1.6	4.8	.46	Tr	0	.7	.1	1.0	0	0	0	.5	1.6	2.10	399,009
3. BACTERIAL BLIGHT Xanthomonas malvacearum	Tr	.4	.3	2.8	4.0	.5	.2	.5	.5	.5	1.8	3.3	.8	.4	1.27	240,796
4. ROOT ROT Phymatotrichum omnivorum	Tr	2.6	.1	2.45	0.3	0	Tr	Tr	0	0	0	0	0	0	.79	149,627
5. ANTHRACNOSE BOLL ROT Glomerella gossypii	0	0	0	.43	Tr	0	Tr	.5	.3	1.0	.3	.3	.2	.3	.28	52,574
6. SEEDLING DISEASES Rhizoctonia, etc.	3.0	2.6	.6	1.77	2.0	2.5	.9	2.5	3.3	1.0	3.0	2.4	2.5	4.0	2.28	431,473
7. ASCOCHYTA BLIGHT A. gossypii	0	0	0	.13	0	0	0	0	Tr	0	.3	.5	.1	.05	.08	14,234
8. BOLL ROTS Rhizopus, etc.	.5	.3	0	.10	.2	0	Tr	1.5	.5	2.0	1.8	1.5	1.0	.1	.55	103,842
9. ROOT KNOT Meloidogyne sp.	4.0	3.0	.3	.73	.2	1.0	Tr	2.0	1.0	3.0	3.5	3.3	3.0	.7	1.70	322,590
TOTAL	20.5	10.5	6.1	8.90	6.7	7.5	4.0	8.6	10.6	8.5	14.2	13.3	10.1	8.85	10.41	1,970,808
II. NON-PARASITIC																
10. OTHERS, including Deficiency Diseases	1.5	1.8	.2	.96	1.5	.5	11.0	2.6	2.8	3.0	4.5	4.5	2.3	6.0	3.06	578,425
TOTAL PERCENT LOSS	22.0	12.3	6.3	9.86	8.2	8.0	15.0	11.2	13.4	11.5	18.7	17.8	12.4	14.9	13.47	
TOTAL BALES LOST	486,538	139,970	22,188	475,826	39,750	38,696	273,529	102,793	331,905	126,045	174,809	150,499	64,123	122,562		2,549,233
TOTAL YIELD IN BALES*	1,725,000	998,000	330,000	4,350,000	445,000	445,000	1,550,000	815,000	2,145,000	970,000	760,000	695,000	453,000	700,000		16,381,000

*BAE, December, 1953

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COMMITTEE ON COTTON DISEASE LOSSES
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SOME PLANT DISEASE PROBLEMS OF JORDAN

Edgar F. Vestal

Plant diseases must have existed in the land that we now know as the Hashemite Kingdom of Jordan, but literature on the subject is almost nonexistent. A valuable source is the considerable amount of work on plant diseases in the area formerly known as Palestine, reported in the publications of the region now known as Israel. Much of this information applies to the Mediterranean coast but there is also much that includes the Jordan Valley and the hills bordering it. The present report includes observations made in all parts of Jordan during the past year and a half, as well as a review of the available literature.

In traveling about Jordan, the first impression is likely to concern the almost complete absence of trees except in a few localities. We are told that at one time the country was forested over the greater portion and that armies overrunning the country from time to time cut the trees down. Certainly the forests are not here today although it is probable that goats had as much to do with the deforestation as man. That forests once existed here is substantiated by the recent successful plantings of Acacia by the Ministry of Forestry, and of fruit trees such as peaches, apples, pears, apricots, plums, cherries, and almonds, by the Ministry of Agriculture, on lands where the rainfall is not more than 300 mm (12 inches) a year.

There is little water for irrigation although here and there are wadies with perpetual springs that make cultivation independent of the seasonal rainfall. Most of these are the sites of ancient cities that flourished centuries ago. Their ruins make the country an archeologist's paradise. In this land water has always been the most important factor in man's existence. Climate and topography have changed very slowly and as a consequence crops and methods of culture have apparently remained the same for centuries. Some of the plant diseases may have been present for well over 2000 years. Deuteronomy 28:22 refers to the blasting and mildew and these are again referred to in 1 Kings 8:37. Blasting may be caused by various agencies, but many persons believe that the blasting referred to in Deuteronomy and in 1 Kings was caused by cereal rusts. Both powdery and downy mildews are abundant now in Jordan and must have been so for a long time. Powdery mildew is common on the cereals, including wheat, oats, and barley, in the Jordan Valley, and on the cucurbits throughout Jordan.

Elevation of cultivated land in Jordan varies from 392 meters below sea level at the Dead Sea to slightly over 1000 meters above sea level in the hills of the eastern side of the Jordan Valley, an hour's drive by auto. The corresponding temperature changes are equally great. The hills along the eastern side of the Jordan Valley may be blanketed with over a foot of snow whereas some 30 miles away it rarely frosts. Rainfall is also variable. Ionides and Blake (11) give the highest average rainfall for any place in Jordan over the 30-year period 1901 to 1930 as 672 mm at Salt, on the road between Amman and Jericho, at an elevation between 800 and 900 meters. At the other extreme, the average rainfall for the same period at Bayir, in the desert near the Saoudi Arabian border, was 29 mm. At Amman, 32 kilometers from Salt, the rainfall is 318 mm, while at the Allenby Bridge across the Jordan, some 10 kilometers from the Dead Sea, it is 118 mm. Such extremes are certain to exert a strong influence on the growth of crops and their pests.

The major task of the Cooperative Department for Agricultural Development (United States Operations Mission to Jordan) is to find ways and means of helping the people of Jordan help themselves. Generations of living under foreign domination has deprived them of the means of independence and in many cases even of the will to be independent. Since government has been their only source of help they naturally still look to it for aid. When the United States Operations Mission came into Jordan farmers thought of it as another organization, similar to U.N.R.W.A., to give them the things they needed, including wells, irrigation systems, tractors, sprayers and dusters together with the necessary chemicals, credit, and hundreds of other items. With this sort of background, farmers have been slow to understand the kind of help that the United States Mission can give them, and to realize that they must bear the greater part of the responsibility for improvement in their knowledge and circumstances. Nevertheless, it is encouragingly evident that farmers are becoming increasingly aware both of what their difficulties really are and that it is possible to do something about them. They are holding meetings in which the common problems are discussed with the plant protection men (Fig. 1, 2) and are actively seeking advice and help, especially through extension. It is to this purpose that the Cooperative Department for Agricultural Development is putting forth

FIGURE 1. A meeting at Hebron, Jordan with farmers, members of the Ministry of Agriculture, and the United States Mission.

FIGURE 2. Farmers and plant protection men in the orchard of a farmer of Village Samar in the northern part of Jordan. It is in meetings like this in the orchards and fields of the fellaheen that the plant protection men (with helmets in the picture) are able to instruct and advise on the control of plant diseases and insects and to demonstrate machines and chemicals. The United States Mission is adding men and training them as fast as the Jordan Ministry of Agriculture will take them.

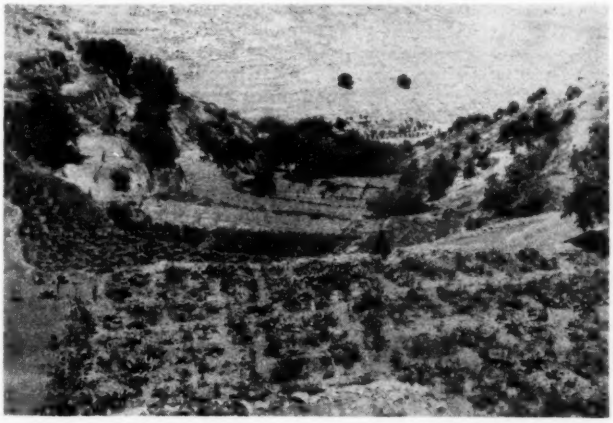

FIGURE 3. Typical of the terrain on which many of the gardens are built. Note rock terraces and the small space inclosed in a single plot. These areas are planted to vegetables, fruits, and more rarely grain. Such small areas are conducive to plant disease and insect spread. Control is restricted to hand units or small power machines. The United States Operations Mission is introducing several small power units for use in such areas. Picture taken near Hebron.

FIGURE 4. Demonstrating the use of hand sprayers and dusters is one of the main activities of the plant protection men. Here Kamal Yahsin of Nablus is demonstrating the use of a knapsack type sprayer to a group of farmers. The machine used is a demonstration machine furnished by the United States Mission. This is being done in all districts of Jordan.

FIGURE 5. Combining dusting and spraying for control of insects and plant disease is quite likely to become a necessity in Jordan. Here the men are spraying and dusting for the control of the olive fly and the olive leaf spot. This is a cooperative project between the Ministry of Agriculture of Jordan and the United States Mission. Hand equipment is being used because the small power units under order had not been received.

FIGURE 6. In contrast to the hand units shown in Figure 5 the Ministry of Agriculture has two power units like the one shown in the picture. They are used where the terrain will permit but so much of the land is not suitable for use of the large units that the United States Mission is bringing in several small power units to demonstrate the advantage of the power sprayer over the hand unit.

FIGURE 7. Root-rotting fungi often attack seed potatoes and young plants. Here the men are treating seed potatoes with Spergon. The United States Mission is cooperating with the farmers in the control of potato diseases. Raouf Halabi, with the hat, is directing a group of Palestinian refugees in a cooperative farming project in the Jordan Valley, an excellent example of what can be done by small groups working together.

its greatest effort. The right sort of extension methods is obviously a primary consideration in the success of the work.

Because of the nature of the terrain over much of Jordan (Fig. 3), the immense amount of labor required to terrace and prepare the land for cultivation, and the limited resources of the fellaheen (farmers), most of the areas now under cultivation are small, often being broken into fields of less than half an acre or even of only a few square meters. The small size of the farms makes impossible any sort of rotation that will prevent spread of wind- and insect-borne pathogens from one portion to another. Thus the farmer is forced to rely on resistant varieties or on chemicals for the control of insects and plant disease. The average farmer knows little about the use of chemicals or the handling of machines. Both money and credit are scarce. The newer fungicides of Europe and America are little known and hard to get. Transportation costs increase the cost of the latter, and agents have difficulty in obtaining American dollars.

Training of farmers to recognize the diseases and pests attacking their crops, demonstration of hand sprayers and dusters as well as small power units or of larger ones where they are adapted, and instruction in the use of chemicals to control seed- and soil-borne diseases, are important in the program of the Plant Protection Section (Figs. 4, 5, 6, 7).

Perhaps the simplest way to discuss the plant disease problems of Jordan will be by crops, which in Jordan means a geographic arrangement as well.

On the eastern border, along the desert, cereals are the most important crop. Cereals are grown in the western part of the country but not to the same extent. Wheat, barley, durra (sorghum), oats, and corn (maize) are most important. Other crops met with in this area are sesame, tobacco, fruits, and some vegetables.

Wheat, for long the most important cereal grown in Jordan, is attacked by stem, leaf, and stripe rusts (Puccinia graminis tritici, P. rubigo-vera tritici, P. glumarum). Fortunately the seasons are too dry for them to become serious year after year. Only in the Jordan Valley are the rusts likely to become limiting factors. Bunt (Tilletia spp.) is much more serious in the southern part of Jordan, where, in the region from Kerak to Ma'an, it is a regular custom to treat seed when mercury or copper dusts are available. In the wadies and in the Jordan Valley, where dews are heavy, powdery mildew (Erysiphe graminis) may become very serious. This past season (1953) a number of the entries of the F.A.O. rust and smut nursery, planted at Deir Alla, in the Jordan Valley, were seriously injured by mildew.

Barley is attacked by stem and leaf rusts (Puccinia graminis, P. hordei) much as is wheat. Covered smut, Ustilago hordei, and semi-loose smut, Ustilago nigra, are common, also stripe (Helminthosporium gramineum) in some seasons. The greatest losses are due to smuts. Seed is treated by informed farmers to whom the copper or mercury compounds are available, but these are in the minority and much has yet to be done in teaching the use and value of these fungicides in the control of smuts.

Oats are grown mostly for forage for animals. They are attacked by stem and crown rusts, usually in a mild form. Crown rust was severe on some of the entries in the rust and

smut nursery planted at Deir Alla in the Jordan Valley this year (1953). Rayss (50) reported Rhamnus palestina heavily infected with the aecidial stage of Puccinia coronata in Jordan. R. palestina is common throughout Jordan but is not considered to be important in the life cycle of P. coronata, since the rust can live over in the uredo-stage. Minz (23) reported that P. graminis tritici and P. graminis avenae were brought into Palestine on one occasion on packing straw used in shipping biological apparatus from the United States. In the same shipment spores of Urocystis tritici and Ustilago avenae were discovered on straw. This was the first appearance of U. tritici in Palestine. It has since been reported on farms in one section. Covered smut, referred to here as Ustilago kolleri, is the most serious of the diseases on oats. Seed treatment is not practiced with oats as much as with wheat or barley.

Sorghum, or durra, is affected by grain smut, Sphacelotheca sorghi, and where seed treatment is not practiced may become serious.

Maize is grown more for the ears, which are eaten after roasting over coals, than for stock food. Soil conditions are not the best for maize. It rarely grows more than 5 or 6 feet tall, with weak spindly stalks. Ustilago maydis and Helminthosporium turcicum are the most important diseases found on maize, with the smut being the more serious. However, until corn becomes more important in the crop rotations of Jordan, smut is not likely to be a major disease.

Sesame (Sesamum orientale) is grown for the oil and is an important crop. It appears to be free from any major disease although it is often attacked by aphids and rotting of foliage may follow. Some tobacco is grown and the culture is being encouraged by tobacco companies operating in Jordan.

Fruits grown in the eastern part of Jordan are attacked by the same group of fungi that cause losses in other parts. These will be discussed later.

As one approaches the Jordan Valley from the east the variety and quantity of agricultural crops increases. More fruits and vegetables begin to appear and one finds small plantings of grapes, peaches, apricots, plums, cherries, apples, pears, figs, pomegranates, olives, and citrus fruits. The vegetable crops include cabbage, cauliflower, lettuce, okra, eggplant, tomatoes, potatoes, carrots, beets, turnips, cucurbits, onions, garlic, beans, and peas.

Jordan with its sunny hills has long been known for the excellence of its grapes. Moses sent spies to look over the land of Caanan before the Children of Israel should go into it. The spies who went to the south, into the area now known as the Hebron District, took back with them a branch with a cluster of grapes as evidence of the fruit of the land. Not many years ago the hillsides were covered with thousands of grape vines producing fruit of the finest quality. Then came the Phylloxera, which spread over the whole land and gradually killed the vineyards. Today one may see thousands of donums (1 donum = 1/4 of an acre) that once bore excellent crops of grapes lying idle because the vines have all been killed by Phylloxera and the land is unsuited for other types of culture in its present condition. Fortunately, American stocks are resistant to the Phylloxera, and new plantings of grapes are being made as rapidly as the stock material can be supplied.

The grape in Jordan suffers from most of the usual diseases. Powdery mildew (Oidium tuckeri) is common and severe. The general recommendation for control in this country is the application of some form of sulphur. Sulphur obtained from the low hills of the Jordan Valley is ground and dusted over the vines. Fortunately, samples that have been analyzed have not been found to contain any injurious chemicals and growers have been able to achieve fair control at minimum expense. Downy mildew (Plasmopara viticola) is more serious in western than in eastern Jordan. Reichert (53) states that downy mildew probably came into Jordan with early shipments of grapes from France, in 1883. Reichert et al. (74) reported that Bordeaux mixture and Perenox (an Imperial Chemical Industries product) were best for downy mildew, superfine sulphur best for powdery mildew control.

A Cercospora leaf spot attacks grapes at times, reducing the foliage and crop. Bordeaux is recommended for control so that the same sprays used against the downy mildew have probably also held the Cercospora in check. Crown gall (Agrobacterium tumefaciens) has been reported on grape roots and a species of Stereum has also been found but neither has been serious. Ravikovitch (48) reported that improper irrigation in the Jordan Valley has been responsible for salt accumulation and severe dieback of the vines with loss of fruit.

Stone fruits are among the most important of Jordan's crops. Three diseases are commonly found. Peach leaf curl (Taphrina deformans) is serious but is not a major problem generally. Sulphur in winter and early spring is recommended. Root rots caused by Pythium and Fusarium spp. are present, but no doubt they often follow borer attack on the roots. It is believed that control of the borers will also largely control the root rots. Rust, Puccinia

pruni-spinosae [?Tranzschelia discolor], also occurs but where control measures are used against peach leaf curl it is not usually important. Crown gall is sometimes found, as is powdery mildew (Oidium sp.), but they are not serious.

Very good pome fruits are grown in Jordan. Many of the varieties came from France and England. Some of the old apple favorites, such as the Gravenstein, are produced with excellent quality. The best flavored apples and pears are grown at elevations between 600 and 1000 meters above sea level and more often without irrigation where the rainfall is not more than 350 mm (14 inches) a season. At Mazur, some 150 kilometers south of Amman, which has an annual rainfall of 347 mm (13.88 inches) per year (Ionides and Blake, 11), apples, pears, peaches, apricots, and plums excelling in appearance and flavor are produced. One might expect that the low rainfall would reduce fungus diseases but in these areas bordering the desert there is a surprisingly heavy dew and fungus spores have ample moisture for germination. It was at Mazur that the heaviest infection of peach leaf curl was observed in 1952.

Apple scab (Venturia inaequalis, referred to in Jordan as Fusicladium dendriticum) is widely distributed (43). Sulphur sprays are recommended for its control. Branch blight (Dothiorella sp.) occurs in some of the older orchards. Powdery mildew (Podosphaera leucotricha) is more common in the western portion. Recommendations for control of the branch blight are pruning out of diseased branches and disinfection of the cuts with some form of copper sulphate. Sulphur sprays are recommended for the powdery mildew. Crown gall is found in nursery stock and in the orchards. At present no regulatory laws covering the sale of nursery stock exist. Root rots caused by Sclerotium bataticola, Fusarium sp., and Polyporellus rhizophilus are present where conditions favor such organisms. Fireblight (Erwinia amylovora) occurs here and there but usually only on a branch or two.

Citrus fruits have long been among the most important fruits of the Middle East and because of extensive shipping from one country to another, with no inspection service worthy of the name, the common insects and diseases are generally distributed over the whole citrus-growing area where climate and varieties are favorable. Oranges, lemons, and grapefruits are attacked by a long list of fungi. In the nursery beds damping-off due to Rhizoctonia, Pythium, and Fusarium is common. Reichert and Perlberger (83) found Phytophthora parasitica and P. citrophthora causing damping-off in seed beds but were able to control it with Ceresan. They found an Alternaria in the diseased seedlings but did not say whether they thought it was connected with the damping-off.

On the stems gummosis is frequently found. Powell (45) stated that by 1928 gummosis was the most serious disease of citrus in Palestine and it still is serious. Powell found Phytophthora citrophthora associated with gummosis, along with P. parasitica. He recommended the replacing of the susceptible sweet limes, Citrus aurantifolia, or Citrus limetta with Citrus bigaradia or Citrus aurantium. Reichert and Perlberger (84) described a disease of citrus in Palestine, which they named "Xyloporosis" because of the porous condition of the wood. Moreira (28) in 1938 considered this condition to be due to incompatibility between stock and scion. The disease has apparently disappeared with the use of other stocks.

Branches are killed by several fungi. One branch blight on oranges caused by Botryosphaeria ribis is controlled by copper sprays. Anthracnose, caused by Colletotrichum gloeosporioides, occurs in the western portion of the country. Recommended control is pruning out diseased branches and spraying with copper. This past season (1953) mature trees in the Ministry of Agriculture Experiment Station at Jericho showed considerable die-back of most of the top portions. Many of the symptoms were similar to those described for the "mal-secco" disease, which has been found in the Valley. Citrus blast, caused by Pseudomonas syringae, occurs in Jordan but has been successfully controlled by copper sprays. A gummosis and branch blight of older orchards caused by Diplodia natalensis is also (54) controlled by copper.

Mal-secco disease, caused by Deuterophoma tracheiphila, has been found on lemon, sour orange, and possibly sweet lemon (64), and has appeared in the Jericho area on orange trees. Sclerotinia sclerotiorum caused a twig blight of lemons in Palestine (64). An exanthema appeared on orange trees growing near the coast. Collar rot and brown rot, which appeared to be caused by a Fusarium, caused losses of from 5 to 50 percent among young trees in Palestine (54).

The fruit of citrus suffers greatest losses from fungi. Blue and green molds cause considerable decay in markets where the fruit is not handled well. Stem-end rot, brown rot, black pit (Pseudomonas syringae), and black rot (Alternaria) are also common. Time of picking influences the amount of molds on the fruit in storage. Shiff (86) found that Palestine

oranges picked in January have less Penicillium digitatum and P. italicum than those picked in March. He also stated that less wastage occurred when oranges were budded on sour oranges than on sweet limes. Reichert and Hellinger (70) found that the two species of Penicillium favored stem-end rot due to Diplodia natalensis at temperatures above 13° C and humidity over 52 percent. The same author (68) reported a rotting of the fruit very similar to the Diplodia rot but caused by a species of Dothiorella. Phomopsis citri was also isolated from stem-end rot. Reichert (57) reported Macrophomina phaseoli associated with stem-end rot of oranges. Reichert and Hellinger (66) stated that stem-end rot is severe in November and December, declines in January and February, and then reaches another peak in March and April. It was suggested that a temperature relationship exists. Perlberger (40) reported Phytophthora citrophthora and P. parasitica causing a fruit rot of sweet limes. Nadel-Schiffmann (27, 28, 29), studying the fungi of the button and rind of the Shamouti orange, found infection caused by Diplodia natalensis, Alternaria sp., and Colletotrichum gloeosporioides. These fungi appear to enter the button through the axis of the petals. Minz (26) stated that Diplodia natalensis attacks the stem end of fruits of old trees more than of young trees and that it is seldom found in the flowers. Colletotrichum gloeosporioides and Alternaria were found in the petals and might be responsible for some of the premature fall of fruit (26).

A considerable amount of dieback of the branches of orange trees in the Jordan Valley seems to be associated mostly with some physiological imbalance. Citrus will not tolerate more than 0.1 percent of sodium chloride, which is sometimes exceeded in the Valley soils. Chlorosis that developed among trees in new plantings appeared to be associated with heat since it has disappeared with cool weather. Apple varieties and some stone fruits, especially apricots, suffer from heat at low altitudes. Soil differences may have something to do with the chlorosis, but so far trials with various chemicals such as urea, iron, zinc, copper, or manganese as sprays have failed to produce results.

Most of the vegetables grown in Jordan are common over the whole Middle East Area. They include the standard varieties.

Tomatoes are one of the most important crops, especially in the Hebron District of the west. Seed-bed diseases are caused by Rhizoctonia, Pythium, and Fusarium and may be serious where not controlled. The recommended treatment with a mercury compound for the seed-bed and a copper spray for the seedlings after emergence is practiced by a few of the more progressive farmers, but many are unable to secure the material and do not know how to apply it.

Powdery mildew (Oidiopsis (Leveillula) taurica) causes serious losses at times. In Jordan the recommendations are for Sulfinette (an I.C.I. product containing 25% to 28% polysulphides) 1.5%, or Spersul (an I.C.I. product containing 73% sulphur) 1%, every 7 to 12 days until the season is over. Reichert and Palti (73) considered copper sulphate as best for control of powdery mildew on tomatoes.

Septoria lycopersici is also common on tomatoes. Copper sprays, such as Perenox or Bordinette, applied every 7 to 12 days, are recommended. Macrophomina phaseoli has been recorded on tomatoes in the field (65), and Rhizoctonia has been isolated from diseased tomatoes (49) in Jordan. Early blight (Alternaria solani) is common on tomatoes and causes some loss but can be controlled by copper sprays. It is often confused with late blight (Phytophthora infestans) and vice versa. Late blight is the most serious of the tomato diseases, with the possible exception of virus diseases. It occurs year after year with fairly constant severity. There is less difference in geographical variation with late blight than with some of the other fungus diseases as the dews are sufficiently heavy wherever host plants are grown to give ample moisture for spore germination. General recommendations are for copper sprays as control.

A tomato fruit organism found in Jordan is Didymella lycopersici. It is thought to have been introduced from Europe where it is common and widespread. Other fruit rot organisms found on tomatoes in the markets of Jordan are bacteria, Alternaria, and Mucor. Losses of fruit in shipment are heavy because of lack of satisfactory packages and proper handling. It is possible that something like the recently developed "Stop Mould" may be helpful in holding in check the various organisms causing decay of the fruit.

Potatoes are subject to most of the same diseases that affect tomatoes. Early and late blight are two of the more common troubles observed during the growing season. Where growers do not have the facilities to spray or dust late blight may destroy most of the crop. Over most of the area the temperature ranges from near frost to over 100° F. The mean annual temperature for the month of January, according to Ionides and Blake (11), ranges from a mean minimum of 31° to a mean maximum of 100° in the Jordan Valley, and from a mean

minimum of 29° to a mean maximum of 104° on the highlands east of the Jordan Valley. The average temperature for the winter months is within the optimum for the late blight organism. However, during the past season late blight was observed to spread gradually throughout the summer months as well. This was especially true where dews were heavy. Wallin (88) has reported gradual spread of late blight on potatoes during summer when temperatures were high and humidities low. In Jordan no rain fell from March until November, so that the only moisture available on unirrigated land was from dew.

Scab (Streptomyces scabies) is found in Jordan, as is Fusarium tuber rot, Rhizoctonia solani and Sclerotium bataticola (Macrophomina phaseoli) are associated with tuber rot. Brown rot (Xanthomonas solanacearum) also occurs where care has not been taken in the selection of seed potatoes. The local varieties Aaron Banner and Up-to-Date are very susceptible. This problem needs study in order to adapt known control measures to local conditions.

Peppers are subject to Cercospora capsici and Oidiopsis sp., which attack the leaves but are rarely serious. Macrophomina phaseoli causes a blight at times (65).

Eggplant is attacked by the organisms that cause damping-off of tomatoes, i.e., Pythium, Rhizoctonia, and Fusarium species. Alternaria solani has been found on eggplant, and a fruit rot caused by species of Pythium and Alternaria also occurs in the fields.

The crucifers are subject to soil-borne organisms such as Fusarium, Rhizoctonia, and Sclerotium. Fusarium root rot may be found at any time of the season but is most evident when soil moisture falls so that the plant begins to suffer from inability to secure enough moisture through the diseased roots. Black rot (Xanthomonas campestris) occurs in the fields but is rarely of major importance.

Probably the most serious disease of cucurbits in Jordan is powdery mildew, Erysiphe cichoracearum. During the past season the yield of cucumbers and squashes in many areas was seriously reduced because of this disease. The usual recommendations here are sulphur dusted over the vines at seven- to ten-day intervals. However, sprayers and dusters are usually not available and hand applications have not given uniform or effective results. Downy mildew (Pseudoperonospora cubensis) is severe on melons and cucumbers. Blossom-end rot, caused by species of Pythium, occurs sometimes, as does anthracnose (Colletotrichum lagenarium).

Beets are attacked by root rotting organisms. Cercospora beticola occurs in every garden. At the present time beets are not grown in large quantities but a search for good varieties is underway. Should beets be grown in quantity it is certain that without resistant varieties Cercospora leaf spot would become serious. Copper sprays are recommended.

Carrots are attacked by powdery mildew, and by species of Alternaria and Cercospora. Sometimes serious leaf blight will occur and root rotting is also found in some cases. Root rotting is serious only on irrigated lands as there is never enough rain to cause the soil to be wet for very long at a time.

Beans and peas are attacked by Ascochyta blight, beans by anthracnose (Colletotrichum lindemuthianum) and rust (Uromyces phaseoli), and broad beans by Botrytis fabae. Copper sprays are recommended locally for all of these fungi, applications being made at 14-day intervals.

Onions suffer from downy mildew (Peronospora destructor) and seed stalk blight (Alternaria sp.). Copper sprays are the local recommendations.

Cotton is being tried in Jordan with variable success. Few diseases are apparent but the leaf hoppers and spiny boll worm will be limiting factors in the Jordan Valley until an effective economical control is found.

Symptoms of virus diseases are common among tomatoes and potatoes in many parts of Jordan. Up to the present time no attempt has been made to study the virus diseases and the only control measures have been to pull out and destroy diseased plants. Leaf roll and purple top symptoms are common, with here and there a plant that appears to be infected with spindle tuber. Jordan does not grow its own seed, but imports most of it from Syria with no inspection service to select disease-free seed. Reichert (66) contended that virus-free potatoes could be grown if virus-free seed were used and roguing practiced faithfully during the season. However, Jordan is inhabited by about all of the chewing and sucking insects known, and effective roguing would be extremely difficult to maintain. Control of insects is difficult and the future hope appears to lie in resistant varieties. Other crops attacked by virus diseases are cucumber, squash, beans, peas, and a number of garden flowers.

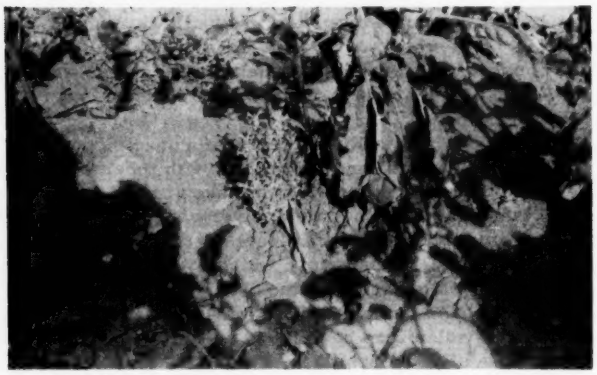

FIGURE 8. Orobanche aegyptiaca is one of the serious pests of many of the garden and field crops. It is generally scattered over Jordan and in some fields can be found on 90 percent of the tomato, eggplant, or other plants.

One of the serious pests, generally distributed and often important, is broomrape (Orobanche) (Fig. 8).

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UNITED STATES OPERATIONS MISSION TO JORDON

UNUSUAL RECORDS ON PLANT DISEASES

THE OCCURRENCE OF HENDERSONULA TORULOIDEA NATTRASS ON POPULUS SPECIES IN CALIFORNIA

By Joseph M. Ogawa

The walnut branch wilt organism, Hendersonula toruloidea Natt., incites a disease of major importance on Persian walnuts and is becoming serious on citrus and figs in California[1]. In Fresno County, the organism was isolated from dead poplar trees (Populus fremontii Wats.[2]), and from dead branches on living poplar trees. In this same district, about eight miles away, the fungus is causing severe damage on walnuts, and about 20 miles away, the pathogen was reported on figs for the first time[3]. The symptoms on poplar were similar to those described on other hosts. H. toruloidea was reported on dead Populus nigra and other hosts in Cyprus, and is found in other Mediterranean countries[4].

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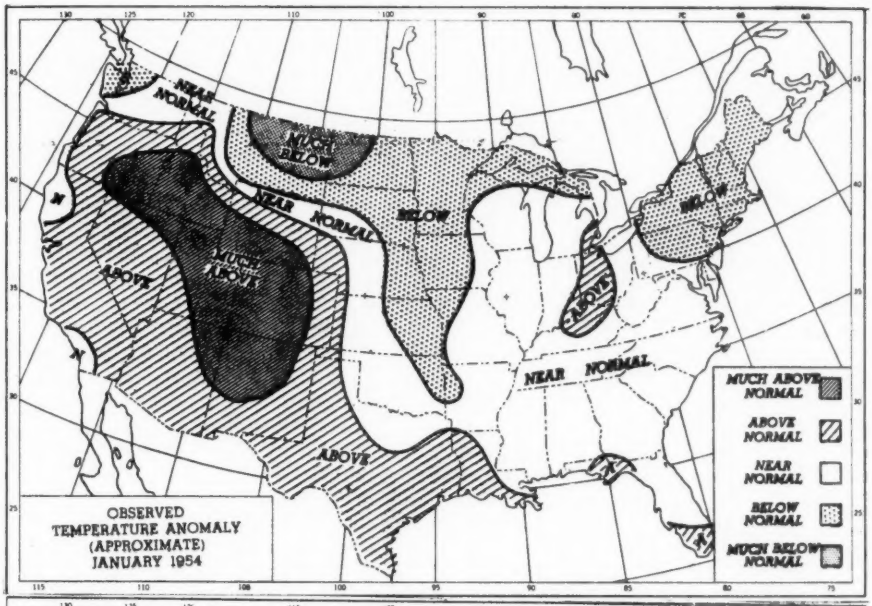
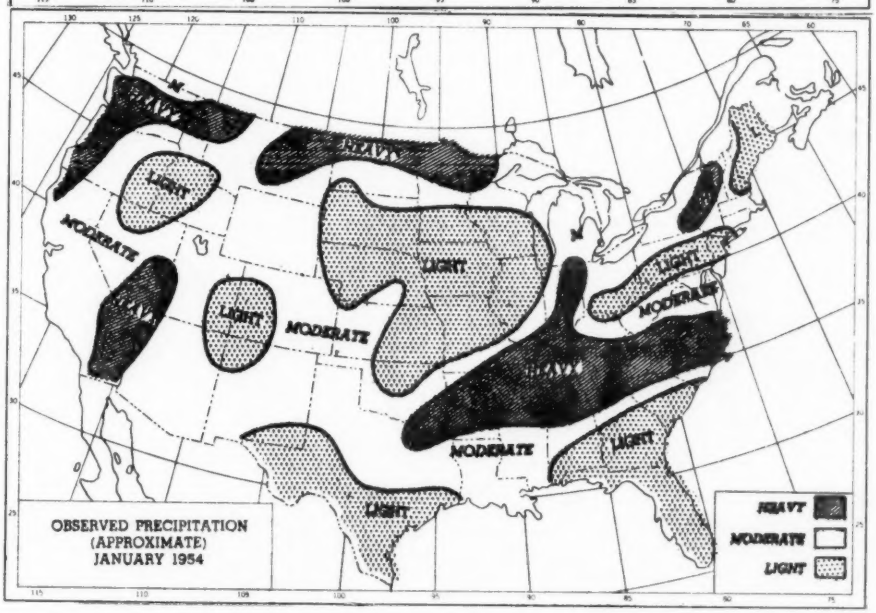
A CORRECTION

John S. Niederhauser sends a correction for page 82 of the February issue. The list under "Other Diseases" should be corrected as follows.

"1) Silver scurf (Spondylocladium atrovirens).
"2) Powdery scab (Spongospora subterranea), locally called 'roña.' This disease, etc."

The other diseases in the list should be numbered "3)", "4)", "5)".





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.